Abstracts

Takeda, T., F. Sakai and T. Hayashi: **Expression of xyloglucan endotransglycosylase during cellulose biosynthesis,** Proceeding of the Third International Wood Science Syposium, 271 (2000).

Transcript of XET was shown in pea stem during cellulose biosynthesis.

Park, Y.W. and T. Hayashi: **The impact of T-DNA tagging line for the rapid analysis of gene-expression patterns,** Proceeding of the Third International Wood Science Syposium, 272 (2000).

Screening of 1, 4-β-glucanase and XET have been shown in Arabidopsis T-tag lines.

Hayashi, T. and Y. Ohmiya: **Cellulose metabolism by endo-1, 4-β-glucanases in poplar,** Proceeding of the Third International Wood Science Syposium, 273 (2000).

The expression of *PopCel1* and of *PopCel2* has been shown in transgenic poplar.

Ohmiya, Y., M. Samejima and T. Hayashi: **Cellulose metabolism by endo-1, 4-β-glucanases in poplar,** Frontiers in Cellulose Science, 8–9 (2000).

Ohmiya, Y., Y.W. Park and T. Hayashi: **Cellulose metabolism in poplar,** Proceedings of Workshop: Interaction between Cell Wall Components, 11–12 (2001).

In the growing leaf of regenerated poplar, *PopCel1 and PopCel2* were complementary and differentially expressed during primary and secondary wall syntheses. The expression of *PopCel1* occurred in the leaf, leaf base, petiole and main vein, whereas that of *PopCel2* occurred in the mesophyll. *PopCel1* expression started in the adaxial side of the leaf base and extended to the petiole and main vein together with the stem, whereas *PopCel2* expression started in the abaxial side of the leaf base, extended to the whole leaf mesophyll and disappeared during leaf development. *PopCel1* and *PopCel2* were also expressed in the columella of the root cap and the elongating zone of root, respectively. The codominant expression of the two genes was observed in the guard cells and the cells dedifferentiated from the leaf. Autoradiography of the leaf showed that the radioactivity of [^{14}C] sucrose incorporated into cellulose corresponded to the sucrose-induced expression patterns of *PopCel1* and *PopCel2*, although 2, 6-dichlorobenzonitrile inhibited the incorporation of the radioactivity into cellulose repressing the expression of both cellulase genes. Repression of cellulase reduced not only leaf growth but also the content of cello-oligosaccharides and cellulose. Thus, we propose that the endohydrolysis of 1, 4-β-glucan is basically associated with cellulose deposition during plant development.

Ohmiya, Y., M. Samejima, M. Shiroishi, Y. Amano, T. Kaneda, F. Sakai and T. Hayashi: **Evidence that endo-1, 4-β-glucanases act on cellulose in suspension-cultured poplar cells,** *Plant J.,* **24,** 147–158 (2000).

Suspension-cultured poplar *(Populus alba)* cells produce two distinct endo-1, 4-β-glucanases, one of which is released in the extracellular culture medium and the other localized in their walls. Two cDNA clones, *PopCel1* and *PopCel2,* isolated from a poplar cDNA library encode the extracellular and the wall-bound endo-1, 4-β-glucanases, respectively, based upon deduced amino acid sequences. The products of these two genes contained domains conserved in endo-1, 4-β-glucanase (family 9) showing 91.5% amino acid identity. The levels of both *PopCel1* and *PopCel2* mRNAs increased during the lag phase of growth and decreased rapidly during the linear phase. After the levels decreased, they were again increased by the addition of sucrose to the culture medium and further enhanced by the addition of 2, 4-dichlorophenoxyacetic acid (2, 4-D) in the presence of sucrose. The accumulation of the mRNAs was correlated with the solubilization of cello-oligosaccharides. Cello-oligosaccharides and xyloglucan were also solubilized from the wall preparations of poplar cells incubated with enzyme preparations from the extracellular culture medium and walls. An antibody against both PopCels reduced the production of cello-oligosaccharides by the extracellular enzyme by 90% and that by the wall-bound enzyme by 55%, and also prevented xyloglucan solubilization. The results show that the accumulation of poplar endo-1, 4-β-glucanases are regulated indirectly by auxin in the presence of sucrose and can act on cellulose in suspension-cultured poplar cells.

Morioka, Y., A. Moriya and F. Sakai: **Structural analysis of Δ^1-pyrroline-5-carboxylate synthetase gene from *Bruguiera gymnorrhiza,*** *Wood Research,* No. **87,** 11–12 (2000).

Δ^1-pyrroline-5-carboxylate synthetase gene *(BgP5CS)* fragment was isolated from mangrove by PCR. The fragment was 4.5 kbp in length corresponding to the truncated region from the second to the fourteenth exon. The deduced amino acid sequence showed high identity with that in various plants and contained both ATP and NADPH-binding domains. BgP5CS should be a bifunctional enzyme which catalyzes the first two steps in proline biosynthesis from glutamate.

Kuroda, H. and K. Kuroda: **Candidate genes involved in water pump of trees,** in "Tree SapII", M.Terazawa ed., pp. 67–75, Hokkaido Univ. Press (2000).

A revised paper of the 2nd International Symposium on Sap Utilization in Bifuka 2000. The water conduit in a pine tree is irreversibly broken by the attack of pathogenic wood nematodes, while it is reversibly broken in intact pine trees. In order to discuss water refilling, we have searched possible biological molecules in the water transport. Among the possible molecules in water transport, it was first experimentally confirmed that a passive water channel, aquaporin, locates in a mature tree xylem.

Kim, Y.J., H. Kuroda and F. Sakai: **Isolation of genomic DNA from Japanese red pine *(Pinus densiflora)*,** *Wood Research,* **87**, 9–10 (2000).

Genomic DNA was extractable from various plants with good quantity and quality by conventional CTAB method. However, the DNA size was not big enough to construct BAC or YAC libraries. For the purpose, methods for the DNA preparation up to 200 kbp in size was examined.

Etoh, K., A. Kodan, F. Sakai and H. Kuroda: **An *O*-methyltransferase (OMT) cDNA clone in Japanese red pine *(Pinus densiflora)* seedlings,** *Wood Research,* **87**, 8 (2000).

An *O*-methyltransferase (OMT) gene carrying full coding sequence was cloned from a cDNA library of the pine seedlings. The sequence suggested the OMT as a kind of AE OMT, which is catalyzing both methylations of cinnamoyl CoA derivatives and cinnnamate derivatives. The gene products, as 60 kDa of the fusion protein, was also overexpressed in *E. coli.*

Kodan, A., H. Kuroda and F. Sakai: **Stilbene synthase from Japanese red pine, its role in stilbenoid biosynthesis,** Proceedings of the 3rd International Wood Science Symposium (full paper), pp. 258–263, Uji (2000).

Three stilbene synthase (STS) genes have cloned from a cDNA library of the pine seedlings. Their phylogenetic relationship and simultaneous expression were discussed. They were expressed in *E. coli* and one of the recombinant enzyme was purified and characterized for the activity.

Okunishi, T., T. Umezawa and M. Shimada: **Enantiomeric compositions and biosynthesis of *Wikstroemia sikokiana* lignans,** *J. Wood Sci.,* **46**, 234–242 (2000).

Thymelaeaceae plants produce dextrorotatory dibenzylbutyrolactone lignans, which were opposite enantiomers to the lignans isolated from other plants, e.g. *Forsythia* spp. In our previous paper, (−)-pinoresinol (74% enantiomer excess), (+)-matairesinol (optically pure), and (+)-wikstromol (optically pure) were isolated from *Wikstroemia sikokiana* (Thymelaeaceae). In the present investigation, a survey of lignans and determination of their enantiomeric compositions were continued. Four lignans, (−)-lariciresinol, (−)-secoisolariciresinol, (+)-kusunokinin, and (+)- methyltrachelogenin, were isolated from MeOH extracts of *W. sikokiana* stem. To our knowledge, (+)-methyltrachelogenin was isolated form plants for the first time. Chiral high performance liquid chromatographic analysis showed that (+)-kusunokinin and (+)-methyltrachelogenin were optically pure, whereas (−)-lariciresinol and (−)-secoisolariciresinol were not (39% and 45% enantiomer excess, respectively). Feeding experiments with deuterium-labelled substrates demonstrated conversion of coniferyl alchhol to the lignans and interconversion of lignans. These reaction sequences are similar to the sequence catalyzed by *Forsythia* enzymes. However, predominant enantiomer of the lignans except for secoisolariciresinol isolated from *W. sikokiana* have opposite absolute configuration to those of the corresponding lignans isolated from *Forsythia* spp. Based on the results of the isolation and the feeding experiments, several differences between *W. sikokiana* and *Forsythia* spp. were pointed out regarding stereochemical mechanisms for lignan biosynthesis.

Umezawa, T.: **Biochemistry and molecular biology of cinnamate pathway (in Japanese),** *Wood Research and Technical Notes,* No. **36**, 17–33 (2000).

Recent advances in biochemistry, molecular biology, and metabolic enzineering of the cinnamate pathway, especially in relation to lignin biosynthesis, were reviewed.

Umezawa, T.: **Chemistry of extractives,** In "Wood and Cellulosic Chemistry 2nd Ed. revised and expanded" (Eds. Hon, D.N.-S. and Shiraishi, N.), Marcel Dekker, New York, pp. 213–241 (2000).

Chemistry of wood extractives were outlined.

Tanaka, S., Y. Sakata, K. Morimoto, Y. Tambe, Y. Watanabe, G. Honda, M. Tabata, T. Oshima, T. Masuda, T. Umezawa, M. Shimada, N. Nagakura, W. Kamisako, Y. Kashiwada and Y. Ikeshiro: **Influence of natural and synthetic compounds on cell surface expression of cell adhesion molecules, ICAM-1 and VCAM-1,** *Planta Med.,* **67**, 108–113 (2001).

Various natural and synthetic compounds including alkaloids, terpenoids and phenolics were tested for inhibition of the cell surface expression of intercellular adhesion molecule-1 (ICAM-1) and vascular cell adhesion molecule-1 (VCAM-1), both of which are crucial in the regulation of immune response and inflammation. Of 40 compounds tested, two compounds significantly downregulated the expression of VCAM-1 on murine endothelial cells (F-2) and ten compounds that of ICAM-1 on mouse myeloid leukemia cells (M1). Sanguinarine chloride (5) and isoliquiritigenin (13) were capable of lowering the levels of both ICAM-1 and VCAM-1. The structure activity relationships study on chalcone and flavone derivatives related to 13 suggested that the inhibitory activity of the chalcone derivatives is attributable to the 4-hydroxy group as well as the possible coplanarity between the phenyl ring and the adjacent conjugated ketone.

Umezawa, T.: **Biosynthesis of lignans and related phenylpropanoid compounds (in Japanese),** *Regulation of Plant Growth and Development,* **36**, 57–67 (2001).

Recent advances in chemistry, biochemistry, and molecular biology of lignans, norlignans and related compouns were reviewed.

Akitsu, N., T. Hattori, G.-S., Seo, A. Ohta and M. Shimada: **A possible role of oxalate produced in the symbiotic culture system with a host plant *Pinus densiflora* and a mycorrhizal fungus *Lactarius hatsudake*,** *Wood Research,* No. **87**, 13–14 (2000).

We have established the symbiotic system of *Pinus densiflora* associated with *Lactarius hatsudake* in vermiculite culture. The growth of *P. densiflora* seedlings were enhanced in the symbiotic culture. Oxalate produced in the symbiotic culture is suggested to be involved in the growth promotion.

Hayashi, N., T. Tokimatsu, T. Hattori and M. Shimada: **An enzymatic study of an oxalate producing system in relation to the glyoxylate cycle in white-rot fungus *Phanerochaete chrysosporium*,** *Wood Research,* No. **87**, 15–16 (2000).

The changes in the activities of glyoxylate dehydrogenase (GDH), formate dehydrogenase (FDH), and glyoxylate cycle enzymes such as isocitrate lyase (ICL) and malate syhthase (MS) in a white-rot fungus *Phanerochaete chrysosporium* were investigated. The results suggest that the glyoxylate cycle enzymes such as ICL and MS, and GDH and FDH are interlinked with each other and function cooperatively in the production and decomposition of oxalate in the culture of *P. chrysosporium*.

Nishiyama, N., T. Hattori and M. Shimada: **Dechlorination of trichloroacetic acid by Mn(III)/oxalate system and the enzymatic system of manganese peroxidase/Mn(II)/oxalate,** *Wood Research,* No. **87**, 17–18 (2000).

The enzyme-mimetic dechlorination of trichloroacetic acid (TCA) by Mn(III)/oxalate system and manganese peroxidase (MnP)/Mn(II)/oxalate system were reported. Formate anion radical is suggested to be an active species for dechlorination.

Hattori, T., Akitsu, N., G.-S. Seo, A. Ohta and M. Shimada: **A possible growth promoting effect of the organic acids produced in an axenic symbiotic culture of *Pinus densiflora* and *Lactarius hatsudake* on both of symbionts,** *Ann. Report Interdiscipl. Res. Inst. Environ. Sci.,* **19**, 59–65 (2000).

Production of organic acids in an axenic symbiotic culture of Japanese red pine *(Pinus densiflora)* associated with *Lactarius hatsudake* was investigated and their possible growth promoting effect on both of symbionts was examined. Oxalate accumulated as a major organic acid in the symbiotic culture, whose amount was more than 100 times that in the control *P. densiflora* culture. However, there was no statistically significant difference in amounts of oxalate accumulated in free-living and symbiotic cultures. On the other hand, succinate accumulated in the control *P. densiflora* culture but neither succinate secreted from *P. densiflora* was utilized by *L. hatsudake* in the symbiotic culture. Besides, lactate and small amounts of malate and citrate were detected from the symbiotic culture. Furthermore, oxalate, succinate and citrate promoted the hyphal growth of *L. hatsudake,* Thus, the results suggest that organic acids produced by *L. hatsudake* and *P. densiflora* during symbiosis, possibly promoted the growth of both symbionts.

Hattori, T. and M. Shimada: **Microbial, enzymatic, and biomimetic degradation of lignin in relation to bioremediation,** In "Wood and Cellulosic Chemistry 2nd Ed. revised and expanded" (Eds. Hon, D.N.-S. and Shiraishi, N.), Marcel Dekker, New York, pp. 547–571 (2000).

Microbial, enzymatic, and biomimetic degradation of lignin in relation to bioremediation were reviewed.

Suzuki, K. and T. Itoh: **The changes in cell wall architecture during lignification of bamboo, *Phyllostachys aurea* Carr.,** *Trees* **15**, 137–147 (2001).

The cell wall architecture of bamboo at various developmental stages of culm growth was investigated by rapid-freezing and deep-etching (RFDE) electron microscopy. The unlignified primary wall (ULP) was characterized by the narrow spacing between the cellulose microfibrils in fibres, but not in parenchyma cells. The unlignified secondary wall (ULS) largely consisted of dense cellulose microfibrils with narrow spacing or "slit-like" pores. However, such pores are difficult to observe in the lignified secondary wall (LS) of fibres. The cell wall architecture of the delignified secondary wall (DLS) in fibres showed porosity similar to that of ULS. Pores in the middle lamella and secondary walls of ULS in fibres were reduced considerably or disappeared immediately after lignification. However, the pores reappeared following delignification. These findings suggest that deposition of lignin in ULS immediately proceeds in the pores during maturation to LS. Based on RFDE electron microscopic images, the pore sizes of primary and secondary fibre walls were significantly smaller in bamboo than in either Eucalyptus or Pinus, suggesting a denser arrangement of cellulose microfibrils in bamboo fibre walls than in either tree species. The author hypothesizes that the narrow spacing between cellulose microfibrils in bamboo fibres may be one of the reasons for the deposition of less lignin in bamboo than in tree species. This is the first report on the three-dimensional architecture of unlignified and lignified walls in bamboo.

Kimura, S., C. Ohshima, E. Hirose, J. Nishikawa and T. Itoh: **Cellulose in the house of the appendicularian *Oikopleura rufescens*,** *Protoplasma,* **216**, 71–74 (2001).

Using electron diffraction analysis, highly crystalline cellulose Iβ was found in the house (a special structure in which the tunicate lives) of an appendicularian, Oikopleura rufescens. The cellulose microfibrils of 20 nm in width were observed in a random array or highly organized with 2 to 10 nm rectangular spacings in the house. The bundled cellulose microfibrils formed in the inlet filters, which are highly ordered meshwork structure. The paper provides first account for the existence of cellulose in the house of the appendicularian. The evidence shows that the house and tunic are homologous tissue among the tunicates, and that the common ancestor of the tunicates (ascidians, thaliaceans, and appendicularians) had already possessed the ability of the cellulose biosynthesis.

Ohashi, Y., H. Mohd N. Sahri, N. Yoshizawa and T. Itoh: **Annual rhythum of xylem growth in rubberwood *(Hevea brasiliensis)* trees grown in Malaysia,** *Holzforschung,* **55**, 151–154 (2001).

The periodicity of the growth increment in six rubber wood (*Hevea brasiliensis* Muell. Arg.) trees grown in Peninsula Malaysia was investigated for three years using the pinning and band-dendrometer methods.

The data of growth increments measured with the dendrometer for three years indicated growth dormancy during the first three to five months (from January to

March or May) each year in all the sample trees, in which annual ring-like features were observed. This means that rubber wood trees have an annual rhythm in the xylem growth. The boundary zone consisted of flattened wood fibers with thinned walls, axial parenchyma cells, and small vessels. On the other hand, those obtained from the pinning method showed a vague growth dormancy around March every year. It seemed that growth measurement in tropical trees using the dendrometer is useful for detecting the growth rhythm of cambium.

Ohyama, M., K. Baba and T. Itoh: **Wood identification of Japanese *Cyclobalanopsis* species (Fagaceae) based on DNA polymorphism of the intergenic spacer between *trn*T and *trn*L 5′exson,** *J. Wood Sci.*, **47**, 81–86 (2001).

DNA was extracted from wood samples of six representative *Cyclobalanopsis* species (Fagaceae) growing in Japan that cannot be distinguished from one another by conventional microscopy. A part of the intergenic spacer region between *trn*T and *trn*L 5'exon was amplified and sequenced. The sequences obtained from wood samples were grouped into three DNA types by a single nucleotide polymorphism as reported previously in leaf samples: I *(Quercus acuta, Q. sessilifolia, Q salicina)*, II *(Q. myrsinaefolia, Q. glauca)*, and III *(Q. gilva)*. Thus, *Q. gilva* can be distinguished from the other *Quercus* species, and the others are separated in two subgroups based on DNA polymorphism. The present findings support the possibility of wood identification based on DNA polymorphism.

Suzuki, K., S. Kitamura, Y. Kato and T. Itoh: **Highly substituted glucuronoarabinoxylans (hsGAXs) and low-branched xylans show a distinct localization pattern in the tissues of *Zea mays* L.,** *Plant & Cell Physiol.*, **41**(8), 948–959 (2000).

Polyclonal antibodies which recognized highly substituted glucuronoarabinoxylans (hsGAXs) and low-branched xylans and did not cross-react with each other, were raised in order to examine localization of these epitopes in internodes of maize. Immunofluorescent labeling revealed different pattern between two succeeding developmental stages. The hsGAX epitope was localized evenly in primary walls in all tissue types, and strongly in unlignified secondary walls in phloem. However, lignified secondary walls in protoxylem, parenchyma and a part of fibers were faintly labeled with this epitope. Moreover, the epitope showed limited binding in lignified parenchyma and fiber walls at ultrastructural level. Low-branched xylan epitope was localized evenly throughout lignified walls in all tissue types. This epitope was also localized only in lignified walls of other organs such as leaf, root apex and dark-grown mesocotyl. Low-branched xylans are significantly related to lignification. Localization of hsGAX epitope in their organs was similar to that in internodes. The hsGAX epitope was distributed both in unlignified walls of all tissues and in lignified walls of parenchyma and annular thickening of protoxylem. We propose that hsGAX has separate functions in lignified and unlignified tissues. In conclusion, at tissue level, hsGAX is localized mainly in unlignified walls, and low-branched xylans in lignified walls.

Fujino, T., Y. Sone, Y. Mitsuishi and T. Itoh: **Characterization of cross-links between cellulose microfibrils, and their occurrence during elongation growth in pea epicotyl,** *Plant & Cell Physiol.*, **41**(4), 486–494 (2000).

The occurrence and chemical nature of the cross-links between cellulose microfibrils in outer epidermal cell walls in Pisum sativum cv. Alaska was investigated by rapid-freezing and deep-etching technique coupled with chemical and enzymatic treatments. The cell wall in the elongating region of epidermal cells was characterized by the absence of the cross-links, while in the elongated region, the cell wall was characterized by the presence of cross-links. The cross-links remained in the cell wall of the elongated region after treatment with SDS electrophoresis sample buffer and treatment with 4% potassium hydroxide. After treatment with endo-1, 4-b-glucanase, which fragments xyloglucan, the cross-links were remarkably reduced from the cell wall of the elongated region. The endoglucanase treatment also reduced immunogold labeling of xyloglucan in the cell wall. The endoglucanase hydrolysate from the cell wall fraction of the elongated region gave spots of oligosaccharides in thin layer chromatography, which were identical to the spots of xyloglucan oligosaccharides produced by xyloglucanase from both the cell wall fraction and tamarind xyloglucan. These results indicate that the cross-links are made of xyloglucan. We discussed the possibility of cross-links involved in the control of mechanical properties of the cell wall.

Matsuoka,T., D. Tokumori, H. Kotsuki, M. Ishida, M. Matsushita, S. Kimura, T. Itoh and G. Checcucci: **Analyses of surface of Photoreceptor organelle and blepharismin-associated protein in unicellular eukaryote *Blepharisma*,** *Photochemistry and Photobiology*, **72**(4), 709–713 (2000).

In the ciliated protozoan *Blepharisma*, step-up photophobic response is believed to be mediated by a novel type of photosensory pigment known as "blepharismins" (BL) that are contained in the pigment granules located just beneath the plasma membrane. We examined the ultrastructure of the pigment granules by freeze-fracture and thin-section electron microscopy and proposed a schematic diagram showing the granules' three-dimensional inner membraneous structure. Some of the BL are suggested to be associated with 200 kDa membrane protein. High-pressure liquid chromatography analysis of pigment species associated with 200 kDa membrane protein obtained from blue forms of *Blepharisma* (oxyblepharisma) revealed that the 200 kDa protein was associated with five types of oxyblepharismin. The fluorescene intensity was increased when the pigments were dissociated from the 200 kDa protein. The result supports the hypothesis that the pigment-200 kDa complex is able to transduce light energy into signals mediating the photobehavior of *Blepharisma*.

Itoh, T., M., Kuwahara and H. Sasaki: **Solar boat and Lebanon cedar,** *Magazine for quality of life*, 38–41 (2001) (in Japanese).

The relation between solar boat and Lebanon cedar was

described with the following headings : the finding of solar boat, tree species used for solar boat, Lebanon cedar and Japanese cedar, the burial of dead and the insence of Lebanon cedar, carbon dating, why the solar boat was disintegrated ?, the effect of overflood.

Itoh, T. : **Wood identification of selected wooden treasures,** *Bulletin of Shoshou-in,* No. **23**, 20–21, 29–34 (2001) (in Japanese).

The selected wood artifacts stored in Shosou-in were identified Either by macroscopically or microscopically.

Itoh, T. : **Identification of wood, "The Experimental Manual for Wood Science",** The Japan Wood Research Society, 76–83 (2000) (in Japanese).

The method for the identification of Japanese wood was described with the following headings : The macroscopic method for the identification of softwood, the macroscopic method for the identification of hardwood, the microscopic method for the identification of softwood, and the microscopic method for the identification of hardwood.

Itoh, T. : **Cell wall,** *Electron Microscopy,* **35**(2), 147–148 (2000) (in Japanese).

The history of cell wall research in Japan was briefly reviewed for the celebration of 50th anniversary of the Japanese Society of Electron Microscopy.

Kimura, S. and T. Itoh : **Formation and function of cellulose in ascidian,** *Cellulose Commun.,* **7**(3), 117–120 (2000) (in Japanese).

Recent progress for the understanding of the formation and function of cellulose in ascidians is described.

Itoh, T. : **Wood and Cultural Properties,** *Mokuzai Gakkaishi,* **46**(4), 267–274 (2000) (in Japanese).

The contribution of wood anatomy for the understanding the relation between wood and cultural properties was described with the following headings : introduction, wood identification, wooden cultural properties, wooden buildings, buddha sculptures, National treasures in Shosou-in, excavated wood, buried wood, foreign archaeological sites and wood, and conclusion.

Itoh, T. : **Tree species of printing type used in temples,** *Research Report of Printing types found in Enryakuji Temple,* The Board of Education in Shiga Prefecture, 150–152 (Text), 214–215 (Figures) (2000) (in Japanese).

Tree species of 100 printing types among ca 184,000 were identified microscopically. Seventy seven were identified as *Prunus* sp., nine as *Betula* sp., one as *Fugus* sp. and *Cryptomeria japonica.*

S. Kobayashi, L.J. Hobson, J. Sakamoto, S. Kimura, J. Sugiyama, T. Imai and T. Itoh : **Formation and structure of artificial cellulose spherulites via enzymatic polymerization,** *Biomacromolecules,* **1**, 168–173 (2000).

The in-depth structural analysis of spherulites of artificial cellulose, formed by the enzymatic polymerization of cellobiosyl fluoride, is reported. Both positive- and negative-type spherulites were observed by the polarization optical microscopy. The scanning electron microscopy revealed that the negative spherulites have a three-dimensional round shape, where plate-like single crystals of the artificial cellulose originate radially from the center. Transmission electron microscopy clarified that the cellulose chains orient vertically in the plate-like crystals, which explains the observation of the negative-type spherulites by the polarization optical microscopy. Cellulose spherulites can be formed only by the enzymatic polymerization, and the occurrence of two types of spherulites should be due to two independent types of polymerization.

Sakamoto, J., J. Sugiyama, S. Kimura, T. Imai, T. Itoh, T. Watanabe and S. Kobayashi : **Artificial chitin spherulites composed of single crystalline ribbons of α-chitin via enzymatic polymerization,** *Macromolecules,* **33**, 4155–4166 (2000).

A crystalline product of artificial chitin by chitinase-catalyzed polymerization of a chitobios oxazoline derivative was investigated by using optical microscopy in combination with TEM and SEM techniques. Platelike single crystals of α-chitin were first formed. The crystals were gradually shaped into ribbons by the rapid growth along the a axis with the crystalline thickness being ca. 10 nm. The α-chitin ribbons then aggregated to form bundlelike or dendritic assemblies as the ribbon concentration in solution increased. They grew into spherulites by splaying and branching, which displayed birefringence with a Maltese cross by polarization microscopic observation. The present artificial chitin spherulite, in which a number of α-chitin ribbons radiated from a common center, is completely different from the helicoidal textures composed of α-chitin microfibrils which have been known so far as a typical three-dimensional organization of chitin.

Nakano, T., J. Sugiyama and M. Norimoto : **Contractive force and transformation of microfibril with aqueous sodium hydroxide solution for wood,** *Holzforshung,* **54**, 315–320 (2000).

The mechanism of longitudinal contraction of Yezo spruce (*Picea jezoensis* Carr.) during treatment with aqueous NaOH solution is discussed. The contraction of wood samples increased with an increase in the concentration of NaOH solution and in heating temperature. Measurements of the stress relaxation and the twist angle during the alkali treatment showed that the alkali treatment caused the contractive and twist forces of a tracheid cell wall in longitudinal and tangential directions, depending on the components of contractive force. The temperature dependence of the contraction and the thermodynamics led to the conclusion that the longitudinal contraction of samples is due to that of microfibril via an entropy elastic force.

Baker, A.A., W. Helbert, J. Sugiyama and M.J. Miles : **New insight into cellulose structure by atomic force microscopy shows the I_α crystal phase at near-atomic resolution,** *Biophysical J.,* **79,** 1139–1145 (2000).

The organization of the surface of cellulose is important in cell structure, as well as in industrial processing and

modification. Using atomic force microscopy, we show that the I_α phase of native cellulose first proposed in 1984 and subsequently characterized by a triclinic unit cell exists over large areas of the surface of microcrystals from *Valonia*, one of the most highly crystalline celluloses. There is startling agreement between the observed structure and crystal models, and it is possible to identify the specific crystal face being imaged. The near-atomic resolution images also offer an insight into structural reconstructions at the surface compared to the interior. We are able to assign features in the images to particular side groups attached to the glucose ring and find indications of subtle modifications of the position of surface hydroxyls due to changes in hydrogen bonding.

Sugiyama, J.: **Polymers - natural polymers,** *Densikenbikyou,* **35**(2), 200 (2000) (in Japanese).

Electron microscopic investigations of natural polymers, especially wood and cellulosics, were briefly outlined with particular reference to the works done by Japanese scientists.

Hori, R., J. Sugiyama, T. Itoh and Mueller: **Synchrotron X-ray diffraction analysis of cellulose in developing xylem cell walls from *Cryptomeria japonica*,** *Wood Res.,* **87**, 19–20 (2000).

Preliminary synchrotron X-ray diffraction results on cellulose structure in developing xylem cell walls from the Japanese Sugi tree were presented.

Matsumura, H., J. Sugiyama and W.G. Glasser: **Cellulosic nanocomposites. I. Thermally deformable cellulose hexanoates from heterogeneous reaction,** *J. Appl. Polym. Sci.,* **78**, 2242–2253 (2000).

Partially derivatized cellulose esters were prepared from dissolving-grade wood pulp fibers by reaction with a mixed p-toluene sulfonic/hexanoic anhydride system in a nonswelling (cyclohexane-based) reaction medium. The partially derivatized pulp fibers, which failed to undergo a significant change in shape or appearance during the modification, proved to be resistant to swelling (in water), were thermally deformable, and retained their biodegradability. Because X-ray diffractometry provided evidence for the presence of unsubstituted, ordered cellulose with cellulose I morphology, the thermally reshaped and consolidated sheets were found to consist of commingled mixtures of cellulose esters and cellulose I. The transparent or semitransparent consolidated sheets (depending on the degree of substitution) were found to represent composites in which cellulose I serves as a discontinuous inclusion that reinforces a continuous, partially ordered cellulose ester matrix. The composites, which revealed cohesive or adhesive failure at rupture, depending on the degree of substitution, had modulus values and tensile strengths as high as 1.3 GPa and 25 MPa, respectively.

Yamanaka, S., M. Ishihara and J. Sugiyama: **Structural modification of bacterial cellulose,** *Cellulose,* **7**, 213–225 (2000).

The microfibrillar nature of bacterial cellulose produced by Acetobacter was modified by various chemical reagents in a culture medium. The chemical reagents included antibiotics to inhibit cell division or certain protein synthesis, and reducing reagents that induce reductive cleavage of disulfide bonds in proteins. Among the reagents tested, nalidixic acid and chloramphenicol induced elongation of bacteria, resulting in the formation of wider cellulose ribbons or aggregates of ribbons. The Young's modulus of the sheets made from such cellulose increased, while dithiothreitol, which produced ribbons having only 45% of the width of the control, produced sheets with undiminished Young's modulus. Although further study is necessary to clarify the effect of such modifications, nalidixic acid and chloramphenicol produced a bacterial cellulose with superior mechanical properties.

Wada, M., L. Heux, A. Isogai, Y. Nishiyama, H. Chanzy and J. Sugiyama: **Improved structural data of cellulose III_I prepared in supercritical ammonia,** *Macromolecules,* **34**, 1237–1243 (2001).

Highly crystalline cellulose III_I samples were prepared by subjecting oriented films consisting of an assembly of Cladophora cellulose microcrystals to supercritical ammonia. Diffraction data recorded on these specimens indicated that the crystals of cellulose III_I could be fully described with a one-chain unit cell and a $P2_1$ space group, with the cellulose chain axis on one of the 2_1 screw axes of the cells. The new cell had the following parameters: $a=0.448$ nm, $b=0.785$ nm, c (chain axis) $=1.031$ nm, $\gamma=105.1°$. In this cell, which is half of the one proposed so far for cellulose III_I, one glucosyl residue becomes the asymmetric unit. A good agreement between the diffraction analysis and spectroscopic data was observed. ^{13}C CP/MAS spectra of the samples presented only six sharp resonance peaks, attributed to the six carbons of the asymmetric glucosyl residue. In these spectra, the occurrence of the C6 signal at 62.3 ppm is a clear indication that the hydroxymethyl moiety is in the gt conformation. FT-IR spectra of cellulose III_I were recorded that showed that in the OH stretching region, there was only one very sharp absorption band that was polarized parallel to the fiber direction as opposed to two broad bands polarized perpendicular. A comparison of the spectroscopic data of cellulose III_I with those of the other cellulose allomorphs suggest that the single chain of cellulose III_I may have some conformational similarities with one of the two chains existing in the crystal of cellulose II.

Watanabe, T., A. Ishibashi, Y. Ariga, M. Hashimoto, N. Nikaido, J. Sugiyama, T. Matsumoto and T. Nonaka: **Trp122 and Trp134 on the surface of the catalytic domain are essential for crystalline chitin hydrolysis by *Bacillus circulans* chitinase A1,** *FEBS Lett.,* **494**, 74–78 (2001).

From the 3D-structural analysis of the catalytic domain of chitinase A1, two exposed tryptophan residues (W122 and W134) are proposed to play an important role in guiding a chitin chain into the catalytic cleft during the crystalline chitin hydrolysis. Mutation of either W122 or W134 to alanine significantly reduced the hydrolyzing activity against highly crystalline β-chitin microfibrils.

Double mutation almost completely abolished the hydrolyzing activity. On the other hand, the hydrolyzing activity against either soluble or amorphous substrate was not reduced. These mutations slightly impaired the binding activity of this enzyme. These results clearly demonstrated that the two exposed aromatic residues play a critical role in hydrolyzing the chitin chain in crystalline chitin.

Wada, M., T. Okano and J. Sugiyama : **Allomorphs of native crystalline cellulose I evaluated by the two equatorial *d*-spacings,** *J. Wood Sci.*, **47**, 124–128 (2001).

The aim of this study was to develop a facile method for categorizing native celluloses into the algal-bacterial type or the cotton-ramie type and for estimating the I_α/I_β (triclinic/monoclinic) ratio of the cellulose samples. We investigated various relatively highly crystalline native celluloses by X-ray diffractomery, and the discriminant analysis was carried out using two equatorial *d*-spacings : *d*1 ; 0.59–0.62 nm, *d*2 ; 0.52–0.55 nm. All of the samples were classified into the two groups without error. The function to discriminate between two groups is represented as $Z=1693\ d1\ -902\ d2\ -549$, where $Z>0$, the algal-bacterial (I_α rich) type; $Z<0$, the cotton-ramie (I_β dominant) type. Further successive X-ray diffractometry study of hydrothermal treated Cladophora cellulose revealed the relationship between d-spacings (*d*1, *d*2) and the I_α/I_β ratio. A calibrating equation by which the I_α/I_β ratio was estimated from the two parameters, d_1 and d_2, was then prepared. In the case of relatively highly crystalline native celluloses, it was found that the I_α/I_β ratio is easily determined by applying the two parameters in the equation.

Baba, K. : **Mechanical stress and plant tissue,** Plant Physiology Lecture 5, Asakura Shoten (Tokyo), 153–160 (2001) (in Japanese).

The changes of plant tissue under mechanical stress were reviewed. Especially, the characteristics of reaction wood and the current studies on the mechanism of reaction wood formation were summarized.

Hirano, T., Y. Honda, T. Watanabe and M. Kuwahara : **Degradation of bisphenol A by the lignin-degrading enzyme, manganese peroxidase, produced by the white-rot basidiomycete, *Pleurotus ostreatus*,** *Biosci. Biotechnol. Biochem.*, **64**, 1958–1962 (2000).

Degradation of 2, 2-Bis(4-hydroxyphenol)propane (bisphenol A, BPA), an endocrine-disturbing chemical, by the growing mycelia of the white-rot basidiomycete, *Pleurotus ostreatus*, was examined. About 80% of BPA initially present decreased in 12 days of sulture with this fungus. By *in vitro* experiments using liginin-degrading enzymemanganese peroxidase (MnP), BPA was metabolized to phenol, 4-isopropanylphenol, 4-isopropylpohenol, and hexestrol. The degradation products of BPA was assumed to be formed by the one-electron oxidation of the substrate.

Yoshida, S., A. Chatani, Y. Honda, T. Watanabe and M. Kuwahara : **Reaction of manganese-dependent peroxidase from *Bjerkandera adusta* in aqueous organic media,** *J. Mol. Cat. B Enzymatic.*, **9**, 173–182 (2000).

The oxidation of various phenolics and aromatic amines by manganese-dependent peroxidase (MnP) of *Bjerkandera adusuta* was examined in aqueous organic media. MnP retained its acitivities in several 70% (v/v) aqueous solutions of water-miscible organisc solvents including ethylene glycol, diethylene glycol, acetone and acetonitrile. The absorption apectra of MnP in these aqueous organic media were similar to that obserbed in the reaction without solvent addition, indicating that the heme of MnP was little affected by the addition of them. MnP was also found to oxidize Mn(II) to Mn(III) in these aqueous organic media.

Iwahara K., Y. Honda T. Watanabe and M. Kuwahara : **Polymerization of guaiacol by lignin-degrading manganese peroxidase from *Bjerkandera adusta* in aqueous organic solvents,** *Appl. Microbiol. Biotechnol.* **54**, 104–111 (2000).

Lignin-degrading manganese peroxidase (MnP) purified from the culture of a wood-rotting basidiomycete, *Bjerkandera adusta,* was applied to the polymerization of guaiacol. MnP was found to catalyze polymerization of guaiacol in 50% aqueous acetone, dimethyl formamide, methanol, ethanol, dioxane, acetonitrile, ethylene glycol and methylcellosolve. Maximal yield of polyguaiacol was achieved in 50% aqueous acetone. Weight average molecular weight (Mw) of the polymer was estimated to be 30,300 by gel permeation chromatography. However, matrix assisted laser desorption ionization time of flight mass spectroscopy (MALDI-TOF-MS) analysis gave a more reliable Mw of 1,690.

IR, ^{13}C-NMR, MALDI-TOF-MS and pyrolysis GC-MS analyses showed the presence of C-C and C-O linkages and quinone structure in polyguaiacol. It was also indicated that polyguaiacol has a methoxy-phenyl group as the terminal moiety. This suggests that polyguaiacol is a branched polymer in which guaiacol units are cross-linked at phenolic group. Thermal gravimetric (TG) and differential scanning calorimetric (DSC) analyses were also carried out. MnP also catalyzed the polymerization of *o*-cresol, 2, 6-dimethoxyphenol and other phenolic compounds and aromatic amines. Mws of these polymers ranged from around 1,000 to 1,500.

Iwahara K., M. Hirata Y. Honda T. Watanabe and M. Kuwahara : **Free-radical polymerization of acrylamide by manganese peroxidase produced by the white-rot basidiomycete *Bjerkandera adusta*,** *Biotechnol. Lett.*, **22**, 1355–1361 (2000).

Acrylamide was polymerized to give polyacrylamide using manganese peroxidase (MnP) in the presence of 2, 4-pentanedione as an initiator. The yield of the polymer was 98% against acrylamide added as substrate. The molecular weight of the polymer synthesized by MnP was 155,000, higher than those obtained with other reaction systems using horseradish peroxidase (HRP) and a redox initiator. The ^{13}C-NMR spectrum showed that acrylamide was polymerized via a free-radical reaction mechanism and the structure of the polymer was atactic. ESR analysis revealed that 2, 4-pentanedione was first

oxidized to generate a carbon-centered radical, which initiated radical additive polymerization of acrylamide. Thermal gravimetric analysis (TGA) showed the polymer was stable to 252°C and completely decomposed at 510°C. The glass transition temperature (Tg) of the polymer was 204°C as determined by differential scanning calorimetry (DSC).

Iwahara K., M. Hirata Y. Honda T. Watanabe and M. Kuwahara : **Free-radical polymerization of acrylamide by manganese peroxidase produced by the white-rot basidiomycete *Bjerkandera adusta*,** *Wood Res.*, **87**, 21–22 (2000).

Manganese peroxidase (MNP), one of the ligninolytic peroxidase produced by the white-rot basidiomycetes, catalyzes oxidation of Mn(II) to Mn (III) in the presence of hydrogen peroxide. Mn(III) withdraws one electron from phenolic compounds including lignin to generate phenoxy radicals. Alternatively, radicals undergo condensation to give the polymerization products. Recently, we reported the synthesis of dehydrogenation polymers from coniferyl alcohol and sinapyl alcohols and polyguaiacol from guaiacol by MnP. This ability to generate radical is considered to apply to the polymerization of vinyl compounds via a radical additive reaction. This paper deals with the polymerization of acrylamide using a lignin-degrading enzyme, MnP.

Watanabe, T., S. Katayama, M. Enoki, Y. Honda and M. Kuwahara: **Formation of acyl radical in lipid peroxidation of linoleic acid by manganese-dependent peroxidase from *Ceriporiopsis subvermispora* and *Bjerkandera adusta*,** *Eur. J. Biochem.*, **267**, 4222–4231 (2000).

Lipid peroxidation by managanese peroxidase (MnP) is reported to decompose recalcitrant PAH and nonphenolic lignin models. To elucidate the oxidative process, linoleic acid and 13(S)-HPODE were reacted with MnPs from *Ceriporiopsis subvermispora* and *Bjerkandera adusta* and the free radicals produced were analyzed by ESR. When the MnPs were reacted with 13(S)-HPODE in the presence of Mn(II), H2O2 and t-NB, ESR spectrum composed of a sharp triplet of acyl radical was observed. Formation of acyl radical was also observed in the reactions of Mn(III)-tartrate with 13(S)-HPODE and with linoleic acid, but the latter reaction occurred explosively after an induction period of around 30 min. Reactions of MnP with linoleic acid in the presence of Mn(II), H_2O_2 and *t*-NB gave no spin adducts while addition of *t*-NB after preincubation of linoleic acid with MnP/Mn(II)/H_2O_2 for 2 h gave spin adducts of carbon-centered and acyl radicals. In contrast to linoleic acid, methyl linoleate and oleic acid were not peroxidized by MnP and chelated Mn(III) within a few hours, indicating that structures containing both the 1, 4-pentadienyl moiety and a free carboxyl group are necessary for inducing the peroxidation in a short reaction time. These results indicate that MnP-dependent lipid peroxidation is not initiated by direct abstraction of hydrogen from the *bis*-allylic position during turnover but proceeds by a Mn(III)-dependent hydrogen abstraction from enols and subsequent propagation reactions involving the formation of acyl radical from lipid hydroperoxide. This finding expands the role of chelated Mn(III) from a phenol oxidant to a strong generator of free radicals from lipids and lipid hydroperoxides in lignin biodegradation.

Watanabe, T., S. Katayama, M. Matsubara, Y. Honda and M. Kuwahara: **Antibacterial carbohydrate monoesters suppressing cell growth of *Streptococcus mutans* in the presence of Sucrose,** *Curr. Microbiol.*, **41**, 210–213 (2000).

The growth inhibitory effect of twenty-four carbohydrate monoesters synthesized by lipases and proteases were assayed to obtain antibacterial agents which suppress the cell growth of *Streptococcus mutans*. Among the carbohydrate esters synthesized, galactose and fructose laurates showed the highest growth inhibitory effect, while the other analogues of hexose laurates showed no antibacterial activity, indicating that configuration of the hydroxyl group in carbohydrate moiety markedly affects the antibacterial activity. The cell growth of *S. mutans* was suppressed by fructose laurates even in the presence of sucrose. Thus, enzymatic synthesis of carbohydrate esters with different core structures have great potential for developing antibacterial agents applicable to food additives.

Watanabe, T.: **Development of cellulo-chemicals: Fermentation products,** in "Recent Advances in Technologies for Wood Chemicals", ed. by G. Meshituka, CMC, Tokyo, 66–84 (2000) (in Japanese).

Fermentation products of cellulosics are reviewed. Recent advances in methane fermentation, ethanol fermentation, microbial and enzymatic isomerization and oxidation of glucose, derivatization of biological functions of cellobiose are described.

Watanabe, T.: **Potential of biomass conversion,** *Bio Industry,* **18**, 66–75 (2000) (in Japanese).

Potential of biomass as renewable resources for energy and chemicals is reviewed.

Watanabe, T.: **Conversion of wood biomass into value-added products—Separation of cellulosics and development of functions of cellooligosaccharides,** *FFI J. Jpn.*, **190**, 6–14 (2000) (in Japanese).

Wood decaying process of selective white rot fungi and biomimetic lignin degradation reactions by metal complex-catalyzed free radical chain reactions of hydroperoxides are described. Biological functions of cellobiose and its related derivatives are also described.

Watanabe, T.: **Free radical generation process of white rot fungi,** *Wood Res. and Technical Notes,* **36**, 34–50 (2000) (in Japanese).

Free radical generation process of white rot fungi including catalytic cycle of lignin-degrading enzymes, lipid peroxidation, and activation of molecular oxygen are reviewed.

Watanabe, T.: **Biomass as resources,** *KagakuKeizai,* 104–111 (2000) (in Japanese).

Biomass resources in Asian region and new technologies for their microbial and enyzmatic conversion are reviewed.

Lamaipis, P., W. Gindl, T. Watanabe and K. Messner: **Lignin degradation by a non-enzymatic system supposed to be active in white rot fungi,** *Proc. of the International Research Group on Wood Preservation,* IRG/WP 00-10340, 1–18 (2000).

Copper complex-catalyzed free radical chain reactions of hydroperoxide, and their potential for pulp bleaching and pretreatments for defibration of wood blocks are discussed in relation to the wood decaying process of selective white rot fungi.

Katayama, S., T. Watanabe, M. Enoki, S. Sato, Y. Honda and M. Kuwahara: **Mn(III)-dependent breakdown of 13(S)-hydroperoxy-9Z, 11E-octadecadienoic acid: A key free radical reaction in lipid peroxidation of linoleic acid by manganese peroxidase,** *Wood Res.*, **87**, 23–24 (2000).

A lipid hydroperoxide, 13(S)-HPODE was reacted with MnPs from *Ceriporiopsis subvermispora,* and the free radicals produced were analyzed by ESR. ESR spectra demonstrated that MnP is able to decompose 13(S)-HPODE to generate acyl radicals, there by suppressing chain-breaking antioxidative effects of Mn(II).

Yamanaka, T., H. Yano, T. Watanabe, Y. Honda and M. Kuwahara: **Application of wood-rot fungi treatment in the production of auto-bonding wood flour moulding,** *Wood Res.*, **87**, 25–27 (2000).

Plastic-like moldings were produced by the treatments of wood-rot fungi and subsequent hot pressing. Treatments with wood rot fungi were found to be effective to reduce energy for the production of plastic-like moldings.

Watanabe, T.: **Production of biodegradable polymers by lignin-degrading fungi and hot pressing treatments,** *Toyota Technical Review,* **50**, 99 (2000).

Research results of a Toyota Advanced Science and Technology Research Project, "Production of biodegradable polymers by lignin-degrading fungi and hot pressing treatments" is reviewed. Treatment of finely divided wood meal with a selective lignin-degrading fungus, *Ceriporiopsis subvermispora* was effective to reduce the energy to make plastic-like moldings with high performance.

Honda, Y.: **Gene cloning and transformation in mushrooms,** in "Review for the mushroom science" ed. by M. Higaki, Chijinshokan, Tokyo, 120–130 (2001) (in Japanese).

Recent developments in molecular cloning and transformation techniques were reviewed in respect of presenting basic and applied science in basidiomycetous fungi to the ordinary people.

Irie, T., Y. Honda, T. Watanabe and M. Kuwahara: **Efficient transformation of filamentous fungus *Pleurotus ostreatus* using single-strand carrier DNA,** *Appl. Microbiol. Biotechnol.*, **55**, 563–565 (2001).

The effects of carrier DNAs on the transformation of the basidiomycete *Pleurotus ostreatus* were analyzed. When lambda phage DNA was added to a transformation mixture containing protoplasts and Cbx^R vector plasmid, an increased number of drug-resistant transformants was observed on a screening plate containing 2 μg carboxin/ml. The highest efficiency (about 200 transformants/μg vector plasmid) was obtained by the addition of heat-denatured DNA, which gave yields approximately 50-fold higher than the control experiment without a carrier DNA. To our knowledge, this is the first report on enhancement in transformation efficiency of fungal protoplasts by single strand carrier DNA.

Irie, T., Y. Honda, T. Watanabe and M. Kuwahara: **Homologous expression of recombinant manganese peroxidase genes in ligninolytic fungus *Pleurotus ostreatus,*** *Appl. Microbiol. Biotechnol.*, **55**, 566–570 (2001).

Pleurotus ostreatus is a white-rot fungus known as an efficient degrader of lignin and also various organopollutants. Using a DNA-mediated transformation system, a molecular breeding approach to isolate overproducers of a manganese peroxidase isozyme, MnP3, was carried out. Recombinant *mnp3* constructs under the control of *P. ostreatus sdi-1* expression signals were introduced into the wild-type *P. ostreatus* strain by co-transformation with a carboxin-resistant vector plasmid, pTM1. One of the recombinants obtained by a mating between two monokaryotic transformants, TMG9-C1, showed a several times higher level of MnP activity than the wild-type control in the early stage of liquid culture. Predominant transcription of the recombinant *mnp3* in the strain was demonstrated by RT-PCR experiments. This is the first report of a genetically modified *P. ostreatus* strain with an expression system for recombinant genes.

Olesnicky, N.S., A.J. Brown, Y. Honda, S.L. Dyos, S.J. Dowell and L.A. Casselton: **Self-compatible *B* mutants in *Coprinus* with altered pheromone-receptor specificities,** *Genetics,* **156**, 1025–1033 (2000).

A successful mating in the mushroom *Coprinus cinereus* brings together a compatible complement of pheromones and G-protein-coupled receptors encoded by multiallelic genes at the *B* mating-type locus. Rare *B* gene mutations lead to constitutive activation of *B*-regulated development without the need for mating. Here we characterize a mutation that arose in the B6 locus and show that it generates a mutant receptor with a single amino acid substitution (R96H) at the intracellular end of transmembrane domain III. Using a heterologous yeast assay and synthetic pheromones we show that the mutation does not make the receptor constitutively active but permits it to respond inappropriately to a normally incompatible pheromone encoded within the same *B6* locus. Parallel experiments carried out in *Coprinus* showed that a F67W substitution in this same pheromone enabled it to activate the normally incompatible wild-type receptor. Together, our experiments show that a single amino acid replacement in either pheromone or receptor can deregulate the specificity of ligand-receptor recognition and confer a self-compatible *B* phenotype. In addition, we use the yeast assay to demonstrate that different receptors and pheromones found at a single *B* locus belong to discrete subfamilies within which receptor activation cannot normally occur.

Tanaka, F. and N. Fukui: **Is the folded-chain structure possible in cellulose molecule?,** *Sen-I Gakkaishi (J. Soc. Fiber Sci. and Tech., Japan),* **56**, 402–409 (2000).

The folded chain structures in cellulose molecule were investigated through molecular dynamics simulation technique. The chain molecules based on the flexible ring structure model of glucose residues were applied for the simulation. The conformational transitions of the ring structures were not detected during the simulation near room temperature. The optimized structures of cellulose chains did not have 2-fold screw axis symmetries that were usually observed in the cellulose chains in the crystallites, so that fairly large stress energies were to be retained in the cellulose crystallites. The comparatively loose folded chain structures were also confirmed to be possible in the cellulose molecules in a cellulose II crystallites that were formed after chain molecules were created.

Nakata, K., H. Sugimoto, M. Inoue and S. Kawai: **Development of compressed wood fasteners for timber construction, Moment resistance of a joint model with a compressed LVL plate and effect of reinforcement by glass fiber sheets,** *Mokuzai Gakkaishi,* **46**(3), 203–212 (2000).

To evaluate the moment resistance of compressed LVL plates, moment resisting drift pin joint models simulating beam-column joints were tested. These joints were comprised of a 9-ply compressed LVL plate of parallel laminates (P-type) or crossbanded laminates (C-type) and two steel plates. Compressed LVL plates including glass fiber sheet layers were also tested. The results were as follows:

1) The P-type plates split parallel to the grain direction. However the C-type plates with more than two crossband layers avoided the splitting failure. The C-type plate was suitable for the connecting plates, but to avoid splitting failures, the C-type plates with enough end- and edge-distance needed two crossband layers, and those with insufficient distances needed three layers.

2) The reinforcement by the glass fiber sheets was effective for the P-type plate and the C-type plate with a crossband layer, where the moment resistance and the rotational stiffness under load perpendicular to the grain of the face veneer were not enough to avoid splitting. However, for the C-type plates with more than two crossband layers, those were enough to do so, and the effect of reinforcement was not significant.

3) Linear stress analyses were conducted of the moment resisting joints employing the compressed LVL plate, based on the anisotropy of the strength and the deformation obtained from bearing strength tests of the compressed LVL plate. The relationships between the experimental and calculated values were in significant correlation and showed that this analysis method was effective for the prediction of the moment resistance of the compressed LVL plate.

Inoue, M., T. Hamaguchi, T. Morooka, T. Higashihara, M. Norimoto and T. Tsunoda: **Fixation of compressive deformation of wood by wet heating under atmospheric pressure,** *Mokuzai Gakkaishi,* **46**(4), 298–304 (2000).

By impregnating wood with organic liquids such as ethylene glycol and glycerin and heating at about 80°C, high swelling was obtained in a short period. The wood was then compressed in the direction perpendicular to the grain and heated at 180°C for more than 60 min to produce compressed wood with high dimensional stability. It was confirmed that liquid remained in the wood cell wall after heating at high temperature, indicating that deformation fixation occurred because wood constituents were heated under swelling conditions at high temperature.

We attempted treatment with aqueous solutions, which is advantageous with regard to efficiency of impregnation, rinsing after processing, and reduction of costs. Also high dimensional stability was obtained by treatment with aqueous solutions of 40% or more glycerin as a swelling agent. Using an aqueous solution of 60% glycerin supplemented with 0.2% sulfuric acid, complete fixation of deformation was obtained by heating at 180°C and compression for shorter than 10 min.

Sekino, N., M. Inoue and H. Yamauchi: **Three-layered particleboards with steram pre-treated face strands—Effects of panel density on the basic properties,** *J. of Soc. Of Material Sci.,* **50**(4), 415–420 (2001).

Mechanical properties of particleboards such as surface hardness, modulus of elasticity (MOE), bending strength (MOR) can be improved by high densification of its face layers. One of the effective ways for this purpose is introducing a steam pre-treatment technique into preparations of wood furnish for face layers, because steaming wood at high temperature increases wood compressibility. Also steam treated and then compressed particles show much less irreversible swelling than ordinary particles. This excellent dimensional stability would contribute to reductions of panel thickness swellings. Three-layered particleboards with a density ranging 0.5–0.8 g/cm^3, a face to core ratio of 2/3, and a thickness of 12 mm were manufactured from Sugi (*Cryptomeria japonica* D. Don) face strands (75×9.0×0.67 mm) and core particles (14.9×2.9×0.97 mm). The face strands were steam pre-treated in an autoclave by introducing high pressure steam at 210°C for 10 minutes. Phenol-formaldehyde resin was used as a binder. The manufactured panels showed the following characteristics, when compared to control panels with non-treated face strands: 1) the maximum density through the thickness increased by 10–15 percent, 2) surface hardness increased by 30 percent, 3) thickness swellings were greatly improved, this being pronounced at higher density panels, 4) however, the reduction of linear expansion was not obvious because this layer structure showed excellent resistance against for in-plane swelling, 5) in spite of face layer's high densification, MOE and proportional limit stress in bending were almost the same as the controls, 6) MOR and withdrawal resistance of wood screw decreased at most by 30 percent due to the reduction of wood cohesion itself caused by steaming.

Inoue, M., K. Adachi and K. Kanayama: **Cup of compressed wood resulting from set recovery,** *Mokuzai Gakkaishi,* **47**(3), 198–204 (2001).

Dimensional change of compressed Sugi (*Cryptomeria japonica* D. Don) specimen in practical size (R : 60, T : 100 mm) by water soaking and boiling was investigated. Not only set recovery in the compressive direction but also markedly cup occurring in concave state related to bark face were observed. The degree of curvature was proportional to increase of compressive deformation.

In the case of transverse compression of flat grained lumber in practical size, it is compressed in the interchangeable from radial to tangential direction near the edge. When the specimen is divided into some parts in width direction and compressed individually, specimens sheared into the state of parallelogram with decreasing annual ring angle to the compressive direction. When the divided specimens were matched again after compression, we could imagine the cup deformation of original specimen. Therefore, compressed wood is considered to be essentially stabilized in the state of cup, accordingly, it is ine vitable to occur the cup on compressed wood with releasing of set by water soaking.

On the compressed wood in practical size, it was possible to decrease the set recovery in compressive direction and the curvature of cup by heat treatment after deformation. In addition, an edge restraint during compression was more effective to reduce the curvature of cup.

Inoue, M., K. Adachi, K. Tsunoda, Y. Imamura and S. Kawai: **Application of roller-pressing method to the novel liquid impregnation treatment of green timber,** Int. Rec. Group on Wood Preserv. Document, No. IRG/WP 01-40198 (2001).

A transverse compression technique enabled us to impregnate liquid into green timber through replacement of the free water in the timber with a treatment liquid without any critical physical damage to the timber by the roller-pressing method. The roller-pressing is supposed to remove free water the cell cavities and to concurrently introduce the treatment solution into green timber in the treatment vessel. This process seems applicable to the preservative treatment of timber without drying prior to the treatment, and definitely contributes to both the reduction of production costs and the greater yield of the products due to the occurrence of the fewer undesirable checks. When *Cryptomeria japonica* D. Don was treated with an aqueous solution of phenolic-resin according to this process, weight gain exceeded 40% and anti-swelling efficiency went up to over 60% even for 1 min immersion period after pressing. Further trials are planned to evaluate biological resistance of the treated timber when fungicide(s) and/or termiticide(s) are incorporated into the treatment solution(s).

Hamdan, S., W. Dwianto, T. Morooka and M. Norimoto : **Softening characteristics of wet wood under quasi static loading,** *Holzforschung,* **54**, 557–560 (2000).

In order to examine the possible influences of temperature on the wood constituents, two groups of wood species namely softwood and hardwood were subjected to heat or steam treatment during large radial compression between 0°C and 200°C. Two well-defined softening regions are observed. Both species showed the glass transition Tg of lignin at around 90°C and around 60°C for softwood and hardwood respectively and a second transition region at around 160°C. The softening behavior between the first and second transition in softwood is in contrast with the softening behavior of hardwood. This difference reflects the difference in the distribution of the relaxation process due to lignin, which suggests the difference in chemical structure of lignin between softwood and hardwood.

Higashihara, T., T. Morooka and M. Norimoto: **Permanent fixation of transversely compressed wood by steaming and its mechanism,** *Mokuzai Gakkaishi,* **46**(4), 291–297 (2000).

Permanent fixation of transversely compressed wood by steaming has been thought to be the result of structural changes of cell wall polymers such as crosslinking or crystallization and release of stored stresses by degradation and/or decomposition of cell wall polymers. To clarify the dominant mechanisms in the permanent fixation, stress relaxation of radial compression and recovery of deformation (strain recovery) in compressed samples of sugi (*Cryptomeria japonica*) wood were examined. Samples were compressed under steam at various times from 0 to 60 minutes and at temperatures from 120°C to 180°C. The compressed samples were immersed in boiling water and then in swelling liquids,i.e., 4% aqueous solution of sodium hydroxide, pyridine or dimethyl sulfoxide (DMSO), and their strain recovery were measured. The relationship between strain recovery in boiling water and residual stress at the end of the relaxation measurements could be expressed by a single curve regardless of time and temperature. The recovery of deformation in swelling liquids was large, especially in DMSO. These findings suggested that the fixation of deformation by steaming was not the result of structural changes of cell wall polymers, such as crosslinking or crystallization, but release of stresses stored in the cell wall and formation of some cohesive structures which were not permanent.

Morooka, T., M. Norimoto and N. Isoda: **Temperature and humidity environment of a large-scale wooden building,** *Mokuzai Gakkaishi.,* **46**(5), 421–430 (2000).

The temperature and humidity environment of a large-scale wooden building (W-building) was compared with that of a steel-frame building (S-building). For all rooms examined, the rooms, in the W-building showed less temperature variation in one day than the rooms in the S-building. This finding agreed well with calculated results based on thermal properties of the wall materials of the room. However, calculating the room temperature in each building by assuming that the W-building and S-building rooms are similar in structure except for the wall materials, the temperature variation was found to be very similar. This indicates that if the room structures are similar there is no great difference in the variation of room temperatures between the W-building and the S-building despite their difference in wall materials. On the other hand, the closed room in the W-building showed substantially less humidity variation in one day than the closed room in the S-building, indicating that the room in

the W-building has a greater humidity control effect than the S-building room. We further observed that the humidity control effect arose not only from the humidity control properties of the wall materials used for interior decoration of the room but also from the structural members of the building.

Yokoyama, M., K. Ohmae, K. Kanayama, Y. Furuta and M. Norimoto: **Changes of dielectric relaxation of wood by acetylation,** *Mokuzai Gakkaishi,* **46**(5), 406–412 (2000).

The longitudinal dielectric constant and dielectric loss of oven-dried acetylated hinoki *(Chamaecyparis obtusa)* wood samples with different percentages of weight gain (WPG) were measured in the temperature range from -150°C to 0°C and in the frequency range from 1 kHz to 1 MHz. By applying a sech law to results of the dielectric loss, relaxation spectra due to the relaxation of methylol groups were calculated. The distribution of relaxation times became broader with increasing WPG and with decreasing temperature, but the relaxation magnitude for sample with different WPG levels was constant irrespective of temperature. As compared with the average relaxation time and the apparent activation energy of the untreated sample, these values decreased slightly in the samples with WPG of 5.4% and 9.7% and increased in the sample with a WPG of 22.5%. The numbers of methylol groups involved in a unit volume of cell wall for the samples with WPG of 5.4, 9.7% and 22.5% were 0.83, 0.71 and 0.43 times that of the untreated sample, respectively.

Yokoyama, M., K. Ohmae, K. Kanayama, Y. Furuta and M. Norimoto: **Mechanical and dielectric relaxations of wood in a low temperature range IV. Dielectric properties of adsorbed water at high moisture contents,** *Mokuzai Gakkaishi,* **46**(6), 523–530 (2000).

The dielectric properties in the longitudinal direction of hinoki *(Chamaecyparis obtusa)* wood were measured at various moisture contents in the temperature range from −150 to 0°C and in the frequency range from 1 kHz to 1 MHz. Almost no volume change of the cell lumen due to water sorption was recognized. Using a parallel model composed of cell wall substance, adsorbed water and cell lumen for wood in the longitudinal direction and applying the sech law to the frequency dependence of the dielectric loss, the dielectric constant at 10 kHz and −80°C as well as the dielectric magnitudes between −90 and −60°C for the cell wall and the adsorbed water at a moisture content of 21.5% were estimated. The dielectric constant and the relaxation magnitude of the adsorbed water were about 60 and 64–79, respectively, which were almost comparable to those of ice and liquid water. The dielectric constant of the adsorbed water at the limiting high frequency was about 4, which was almost equivalent to that of ice and liquid water. With increasing temperature, the dierectric magnitude increased in the adsorbed water, but decreased in ice and liquid water. When compared at the same temperature, the average relaxation time of the adsorbed water was comparable to that of liquid water at high moisture contents and to that of ice at very low moisture contents. The distribution of relaxation times of the adsorbed water was much wider than that of ice and liquid water. The apparent energy of activation of the adsorbed water was greater than that of liquid water and almost equivalent to that of ice.

Yokoyama, M., K. Ohmae and M. Norimoto: **Changes of dielectric relaxation of wood by acetylation II,** *Mokuzai Gakkaishi,* **46**(6), 531–539 (2000).

Water sorption isotherms, longitudinal dielectric properties and anti-swelling efficiencies of hinoki *(Chamaecyparis obtusa)* wood specimens acetylated with acetic anhydride alone were determined and changes in water sorption of wood due to acetylation were investigated. Applying the Hailwood-Horrobin equation to the sorption isotherms obtained, the quantities of hydrated and dissolved water were calculated. The ratio of the quantity of dissolved water to that of hydrated water was almost the same in the specimens regardless of weight percent gain (WPG) below 60%RH, but increased with increasing WPG above 60%RH. The sech law was well applicable to the results of dielectric loss as a function of frequency, and the relaxation spectra due to the motion of adsorbed water for the specimens conditioned at 94%RH were calculated. With increasing WPG, the peak value of the spectra decreased and the distribution of relaxation times became wider. The anti-swelling efficiencies were proportional to WPG and the relaxation magnitude was expressed as a linear function of WPG. The average relaxation time and the apparent activation energy due to the motion of adsorbed water for the specimen with 22.5% WPG was smaller than those for the specimens with 0, 5.4% and 9.7% WPG. From these results, the cluster size of adsorbed water was considered to increase with increasing WPG, although the moisture content of specimen decreased with increasing WPG, although the moisture content of specimen decreased with increasing WPG.

Kawai, Y. Y. Kobayashi and M. Norimoto: **Hybrid drying with high-frequency and hot air under atmospheric pressure II,** *Mokuzai Gakkaishi,* **47**(1), 7–13 (2000).

To obtain effective methods of hybrid drying for sugi (*Cryptomeria japonica*), the relationship between the internal temperature and the internal pressure in square lumber during high frequency (HF) heating under atmospheric pressure was investigated. Hybrid drying combines HF heating and hot air drying. The results are as follows. The core temperature of lumber with high moisture content could not be raised to more than 140°C by HF heating, while the maximum pressure reached 360 kPa. The maximum pressure varied between specimens, which were sealed such that the pressure would not escape at saturated vapor pressure level but that air or water could easily leak at low pressure. Initially, the internal temperature of the core rose prior to that of the intermediate and surface zones in early stage of HF heating. Then the temperature and the pressure in the intermediate zone became higher than those in the core. The temperature and the pressure in the surface zones gradually rose with HF heating time but could not rise as high as that of the intermediate zone. Subsequently, the

temperature and the pressures of the core and the intermediate zone gradually decreased until they became equal in all zones at the final stage of HF heating.

Ohgama T., H. Ishikawa, M. Norimoto and N. Kamba: **Humidity control effects of woods and artificial woods made of ceramics,** *Mokuzai Gakkaishi,* **47**(1), 97–102 (2001).

To obtain necessary guidance for the design and maintenance of a storage building for cultural assets from the viewpoint of humidity conditions, the humidity control effects of six kinds of woods and three kinds of artificial woods made of ceramics were evaluated. The changes of relative humidity and temperature in closed steel boxes lined with these materials when the ambient temperature of the box was changed were measured. The relationship between the logarithm of relative humidity and temperature could be approximated by a straight line. The slope B was used as an index to evaluate the humidity control effect of the materials when humidity changes are caused by temperature changes. The effects of the ratio (A/V) of the lined area (A) to the volume of the steel box (V), and the period of temperature change on the B value was investigated. The results obtained were as follows: In all materials, the B value increased sharply in the low range of A/V and tended to $0°C^{-1}$ in the high range of A/V. The tendency was more remarkable when the period of temperature change was increased. The B value increased almost proportionally to the density of the materials. The humidity control effect of artificial woods was slightly inferior to that of wood when compared at the same density. The estimated amount of moisture which was absorbed or desorbed through a unit area of the materials by a temperature change of 1°C decreased abruptly with increasing A/V, but became about 0.2 g/hm^2 when A/V increased up to 2 regardless of the type of material.

Obataya, E. Y. Ohno, M. Norimoto and B. Tomita: **Effects of oriental lacquer (urushi) coating on the vibrational properties of wood used for the soundboards of musical instruments,** *Acoustic Science and Technology,* **22**, 27–34 (2001).

In order to investigate the possibility of Oriental lacquer (urushi) as a coating for the wooden-soundboard of musical instruments, the effects of urushi coatings on the vibrational properties of wood were compared to those of conventional coatings. By coating, the dynamic Young's modulus of wood decreased slightly in its fiber direction whereas that in the radial direction increased. The most remarkable changes due to coating were recognized in the internal friction of wood (Q^{-1}), especially that in the radial direction. The effect of the urushi coating on the Q^{-1} of wood was relatively small and very close to those of polyurethane coating used for the soundboard of harp. The viscoelastic and mechanical properties of urushi lacquer films were also similar to those of the polyurethane lacquer film. These results suggested the possibility of urushi as a coating for the harp soundboard. The effects of coatings on the vibrational properties of wood were explained by using a model considering three layers, the uncoated wood, coating layer, and a layer consisting of lacquer and wood cell wall.

Obataya, E., T. Ono and M. Norimoto: **Vibrational properties of wood along the grain,** *J. Materials Science,* **35**, 2993–3001 (2000).

The dynamic Young's modulus (E'_L) and loss tangent ($\tan \delta_L$) along the grain, dynamic shear modulus (G'_L) and loss tangent ($\tan \delta s$) in the vertical section, and density (ρ) of a hundred spruce wood specimens used for the soundboards of musical instruments were determined. The relative acoustic conversion efficiency (α, $\sqrt{(E'_L/\rho)}/\tan \delta_L$) and a ratio reflecting the anisotropy of wood (β, (E'_L/G'_L) $(\tan \delta s/\tan \delta_L)$) were defined in order to evaluate the acoustic quality of wood along the grain. There was a positive correlation between α and β, and the variation in β was larger than that in α. It seemed logical to evaluate the acoustic quality of spruce wood by a measure of β. By using a cell wall model, those acoustic factors were expressed with the physical properties of the cell wall constituents. This model predicted that the essential requirement for an excellent soundboards is smaller fibril angle of the cell wall, which yields higher α and higher β. On the other hand, the effects of chemical treatments on the α and β of wood were clarified experimentally and analyzed theoretically. It was suggested that the α and β of wood cannot be improved at the same time by chemical treatment.

Higashihara, T., T. Morooka and M. Norimoto: **Permanent fixation of transversely compressed wood by heating and its mechanism,** *Mokuzai Gakkaishi,* **47**(3), 205–211 (2001).

The permanent fixation of transversely compressed wood by heating has been presumed to be due to the release of stresses stored in the cell wall polymers by their decomposition. It was shown, however, that the permanent fixation by steaming was the result not only of decomposition but also of the formation of some cohesive structures that were not permanent. To clarify whether or not such impermanent structures are formed during heating, the stress relaxation of radial compression and the recovery of deformation (strain recovery) in compressed samples of sugi *(Cryptomeria japonica)* wood were examined. Samples were compressed at temperatures from 160°C to 200°C for various periods of up to 24 hrs. The compressed samples were immersed in boiling water and then in swelling liquids, i.e., pyridine, dimethyl sulfoxide (DMSO) or 4% aqueous solution of sodium hydroxide (NaOH solution), and their strain recovery was measured. The relationship between the residual stress at the end of the relaxation measurements and the strain recovery in boiling water could be expressed by a single curve regardless of heating time and temperature. All the specimens showed greater recovery in the above swelling liquids than in boiling water. In particular, marked recovery was observed in the NaOH solution, even when little recovery was recognized in boiling water for the specimen showing significant weight loss. From these findings, it was concluded that permanent fixation in the heat treatment is associated less with the decomposition of cell wall polymers but is dominated by the formation of some cohesive structures as in steam treatment.

Wong, E., M. Zhang, Q. Wang, G. Han and S. Kawai: **Formation of the density profile and its effects on the properties of fiberboard,** *J. Wood Sci.,* **46**(3), 202–209 (2000).

Medium density fiberboards (MDFs) with various density profiles were manufactured. The formation of density profiles and its effects on the properties of MDFs were discussed.

Suh, J.-S., D. Hermawan and S. Kawai: **Manufacture of cement bonded particleboards from Korean pine and larch by curing of supercritical CO_2 fluid,** *J. Korean Wood Sci. and Tech.,* **28**(4), 41–50 (2000).

Supercritical carbon dioxide curing was successfully applied to the manufacture of cement bonded pine and larch particleboards. The results show that the supercritical carbon dioxide curing shortened the curing time dramatically and enhanced the both mechanical and dimensional properties of boards.

Fujita, T., N. Komatsu and S. Kawai: **Manufacture and properties of gypsum bonded particleboard I. Effect of press time, water-gypsum hemihydrate ratio and resin content on board properties,** *J. Jpn. Wood Res. Soc.,* **47**(2), 120–128 (2001) (in Japanese).

Fundamental production technology of gypsum bonded particleboard was examined. The effect of press time, water-gypsum hemihydrate ratio, and isocyanate adhesive resin addition on the board properties were discussed to obtain optimum manufacturing conditions.

Ohba, S., T. Sasada and S. Kawai: **Development of vertically oriented fiberboard I. Manufacture of fiberboards and analysis of fiber orientation,** *J. Jpn Wood Res. Soc.,* **47**(2), 138–149 (2001) (in Japanese).

Pressed fibers are oriented normal to the pressing direction. Five types of oriented low-density fiberboards were manufactured by changing the directions of pressing fiber mat. The properties of those fiberboards, namely, platen-pressed board, horizontally oriented board, 3-dimesionally random board, extruded board, and vertically oriented board, were examined and compared with each other. Properties of these boards reflect the characteristics of the types of fiber orientation.

Ohba, S., T. Sasada and S. Kawai: **Development of vertically oriented fiberboard II. Fundamental properties of vertically oriented fiberboard,** *J. Jpn Wood Res. Soc.,* **47**(2), 150–158 (2001) (in Japanese).

Various properties of vertically oriented fiberboard were investigated in comparison with those of platen-pressed fiberboard. The low-density vertical oriented fiberboard shows superior characteristics in internal bond strength, compressive MOE, and dimensional stability along the thickness, thus it can be used as a core board for tatami mat.

Han, G., K. Umemura, E. Wong, M. Zhang and S. Kawai: **Effects of silane coupling agent level and extraction treatment on the properties of UF-bonded reed and wheat straw particleboards,** *J. Wood Science,* **47**(1), 18–23 (2001).

Urea formaldehyde resin bonded reed and wheat paritcleboards were manufactured. Effects of the silane coupling agent and ethanol-benzene treatment on the board properties were examined.

Hata, T., K. Umemura, H.Yamauchi, A. Nakayama, S. Kawai and H. Sasaki: **Design and pilot production of a "spiral-winder" for the manufacture of cylindrical laminated veneer lumber,** *J. Wood Science,* **47**(2), 115–123 (2001).

A new spiral-winder was developed for continuous manufacturing of cylindrical laminated veneer lumber (LVL), and a suitable resin adhesive for this cylindrical LVL manufacturing system was investigated.

Kawai, S., K. Ohnishi, Y. Okudaira and M. Zhang: **Manufacture of oriented fiberboard from kenaf bast fibers and its application to the composite panels,** The 2000 International Kenaf Symposium, p. 144–148, Oct. 13–14, Hiroshima (2000).

The Manufacture of oriented medium density fiberboard (MDF) by using long kenaf bast fibers and its application to the composite panels were investigated. A mechanical orientor was newly developed and high-strength MDFs bonded with an isocyanate resin adhesive were successfully manufactured.

Kawai, S. and B. Subiyanto: **Zero-emission processes of oil palm utilization, A short report of the project in the core university program,** Proc. The 3rd International Wood Science Symposium, p. 297, 1–2 November, Kyoto (2000).

Conversion technologies of oil palm residues, such as trunks, fronds, and empty fruit bunches (EFB) were examined to develop the total utilization system of oil palm residues. A case study of the mass flow in palm oil mill and oil palm plantation was investigated in West java, Indonesia.

Wong, E.-D., A. K.Razali and S. Kawai: **Zero-emissions in palm oil industry: Case study of east oil mill, golden hope plantations bhd., Malaysia,** Proc. The 3rd International Wood Science Symposium, p. 153–156, 1–2 November, Kyoto (2000).

A case study of mass flow in palm oil industry in Malaysia was investigated. Analysis of mass and energy flow for the optimzation of oil palm utilization was discussed for the establishnment of the zero-emission process.

Hermawan, D., T. Hata, S. Kawai, W. Nagadomi and Y. Kuroki: **Rapid production of oil palm cement bonded board by using gaseous or supercritical carbon dioxide,** The 3rd International Wood Science Symposium, p. 101–106, 1–2 November, Kyoto (2000).

Effects of curing method using gaseous and supercritical carbon dioxide on the properties of oil palm fronds cement-bonded board manufactured by conventional cold-press setting method. The effect of $MgCl_2$ as an accelerator of cement setting was also investigated. The hydration of cement was examined by using X-ray diffractometry (XRD), thermal gravimetry (TG-DTG), and scanning

electron microscope (SEM).

Firmanti, A., S. Takino, K. Komatsu and S. Kawai: **Fire resistance performance of structurally graded timber of *Acacia mangium*,** The 3rd International Wood Science Symposium, p. 133, 1–2 November, Kyoto (2000).

Hundred fifty pieces of *Accacia mangium* timber were used as test samples. After the density measurement they were mechanically graded and the fire resistance performance of structurally graded timber under loading was tested. The results showed that when timber is structurally graded and proper load is applied based on its strength, the timber indifferent grades tend to have a similar fire resistance to each other.

Kawai, S, S. Ohba, S., T. Sasada, T. and E.-D. Wong: **Evaluation of fiber alignment and its effects on the properties of low density fiberboard,** Proc. 5th Pacific Rim Bio-based Composites Symposium, p. 517–523, 10–13 Dec., Canberra, Australia (2000).

Low-density fiberboards with various fiber alignments were manufactured; platen-pressed (conventional type) fiberboard, horizontally oriented (OSB type) fiberboard, 3-dimensionally random fiberboard, extruded fiberboard, and vertically oriented fiberboard. The fiber alignments of these fiberboards in various planes were evaluated quantitatively using FFT image analyzer, and correlated to the board properties.

Ma, L.-F., H. Yamauchi, O. R. Pulido, Y. Tamura, H. Sasaki and S. Kawai: **Manufacture of cement-bonded boards from wood and other lignocellulosic materials—Relationships between cement hydration and mechanical properties of cement bonded boards,** Proc. 5th Pacific Rim Bio-based Composites Symposium, p. 1–8, 10–13 Dec., Canberra, Australia (2000).

The hydration temperatures of mixtures of cement, additives and powders of sugi, hinoki, bamboo, kenaf, rice husk or rice straw were measured. The relationships between cement hydration and mechanical properties of cement bonded particleboards from these wood and non-wood lignocellulosic materials were examined.

Sulatiningsih, I. M., Nurwatil, S. Murdjooko and S. Kawai: **Effect of bamboo-cement ratio and magnesium chloride content on the properties of bamboo-cement boards,** Proc. The 5th Pacific-rim Bio-based Composites Symposium, p. 36–41, 10–13 Dec., Canberra (2000).

Bamboo cement boards were manufactured from strand like particles of betung bamboo (*Dendrocalamus asper* Backer). The effects of bamboo-cement ratio, magnecium cloride contents on the proeprties of bamboo cement boards were examined.

Ma, L.-F., H. Yamauchi, O.R. Pulido, H. Sasaki and S. Kawai: **Production and properties of oriented cement bonded boards from sugi (*Cryptmeria japonica* D. Don.),** Proc. 5th Pacific Rim Bio-based Composites Symposium, p. 100–105, 10–13 Dec., Canberra, Australia (2000).

Cement bonded oriented strand boards from sugi were manufactured. The boards were cured sufficiently with the addition of calucium chloride at 3.75% and showed high moduli of rupture and elasticity in the orientation direction.

Sasaki, H., H. Yamauchi, L-F. Ma, O.R. Pulido, M. Kataya and S. Kawai: **Technology for the production of cylindrical LVL,** Proc. 5th Pacific Rim Bio-based Composites Symposium, p. 215–219, 10–13 Dec., Canberra, Australia (2000).

The background of the research and development of the cylindrical LVL and the characteristics of the helical winding method are introduced. The effect of the wall structure with interlocked grain, the relationship between the diameter of mandrel and the width of veneer tape, and between the width of veneer tape and the thickness of veneer, and the wet resin paper system of adhesive application were discussed.

Kawasaki, T., H. Kweon, K. Komatsu and S. Kawai: **Shear properties of sandwich panel of plywood-overlaid fiberboard,** Proc. 5th Pacific Rim Bio-based Composites Symposium, p. 415–418, 10–13 Dec., Canberra, Australia (2000).

A sandwich panel (plywood overlaid thick low-density fiberboard) were manufactured. The in-face shearing test method was applied to fiberboard, plywood, and plywood/fiberboard sandwich panel and the shear properties of these boards were discussed.

Pulido, O.R., H. Sasaki, H. Yamauchi, L.-F. Ma and S. Kawai: **Properties of oriented composite boards from wood manufactured by the electrostatic mechanical orientation methods,** Proc. 5th Pacific Rim Bio-based Composites Symposium, p. 534–539, 10–13 Dec., Canberra, Australia (2000).

Results of the studies on the mechanical and electrostatic methods of orientation of wood particles are discussed. When very long rotary cut strands of sugi were oriented in one direction, the resulting boards gave very high strength values. Other types raw materials such as short strands, flakes, particles, and fibers can be oriented better with the electrostatic method.

Pulido, O.R., L.-F. Ma, H. Yamauchi, H. Sasaki and S. Kawai: **Structural integrity of carbon fiber reinforced composites during fire,** Proc. 5th Pacific Rim Bio-based Composites Symposium, p. 775–774, 10–13 Dec., Canberra, Australia (2000).

Several types of adhesives were used instead of the commonly used epoxy resin which have poor durability and resistance to elevated temperatures. The ability of the carbon fibers to block fire spread and maintain the integrity and strength of the composites under different conditions of fire were tested.

Umemura, K. and S. Kawai: **Effect of polyol of isocyanate resin adhesives for wood,** Wood Adhesives 2000 Extended Abstracts, p. 49–50, 22–23 June, South Lake Tahoe, U.S.A. (2000).

The thermal properties of isocyanate (IC) resins prepared with a small amount of polyether polyol and water were investigated. The bond strengths of 3-ply

plywood glued with these polyol contained IC resins were measured. The thermal stability and bond strength of the resins were discussed.

Hayashi, T., A. Miyatake and S. Kawai: **Effects of outdoor exposure on the strength distribution of OSB and particleboard,** Wood Adhesives 2000 Extended Abstracts, p. 89–90, 22–23 June, South Lake Tahoe, U.S.A. (2000).

To study the probabilistic properties and mechanism of strength degradation of wood based panels, outdoor exposure tests and strength tests were conducted. The changes of strength distribution of OSB and particleboard in 5 years of outdoor exposure were discussed.

Han, G., S. Kawai and K. Umemura: **Straw particleboards: Effects of chemical treatments on the board properties,** Proc. 5th European Panel Products Symposium, p. 186–192, 11–13 Oct., Llanduudno, UK (2000).

UF bonded reed and wheat particleboards were manufactured. The effects of silane coupling agent (SCA) levels and ethanol-benzene (EB) treatment on the board properties were examined. The improving mechanism of SCA and EB treatments were discussed.

Kawai, S. and D. Hermawan: **Oil palm cement bonded board by using rapid carbon dioxide curing process,** Intern'l Symp. Efficient Use of Oil Palm Waste as Renewable Resource for Energy & Chemicals (NEDO), p. 43, 23–24 Feb., Kyoto, Japan (2000).

The effects of curing method using gaseous and supercritical carbon dioxide on the properties of oil palm fronds cement-bonded board manufactured by conventional cold-press setting process. The effect of $MgCl_2$ as an accelerator of cement setting was also investigated.

Kawai, S., H. Sasaki and H. Yamauchi: **Bio-mimetic approaches for the development of new composite wood products,** First International Conference of the European Society for Wood Mechanics, p. 511–521, 19–21 April, Lausanne, Switzerland (2000).

This paper deals with the bio-mimetic approaches on plant structure and functions for some developmental works of new wood composite products; those are cylindrical laminated veneer lumber with helically wound and laminated veneer tapes, highly oriented medium density fiberboard with long non-wood lignocellulosic fibers, and vertically oriented low-density fiberboard. The production technology and properties of these newly developed composite products were discussed.

Yamauchi, H., H. Sasaki, , O.R. Pulido and S. Kawai: **Manufacture and application of cylindrical LVL for building materials,** First International Conference of the European Society for Wood Mechanics, p. 253–260, 19–21 April, Lausanne, Switzerland (2000).

Manufacture and application of cylindrical LVL for building materials were briefly reviewed. The winding process most recently employed is introduced and the examples of the cylindrical LVL applied to the building constructions are explained.

Kawai, S.: **An original product in a life,** *Wood Head,* **11,** p. 1 (2000) (in Japanese).

An essay for the developmental works on wood composite products. The perspectives and directions for the future wood composite products were discussed.

Kawai, S.: **Physical utilization of wood biomass,** *Wood Industry (Mokuzai Kogyo),* **55**(11), 517–520 (2000) (in Japanese).

Biomass utilization by physical converson processes are reviewed. The utilization of non-wood lignocellulosic fibers, including agricultural wastes, the zero-emission processes for the rubber/oil palm plantation plants, and the effective utilization of the fast growing species were discussed.

Kawai, S.: **Perspective of the utilization for wood recycled resources,** *Wood Machinery (Mokko Kikai),* **190**, 10–14 (2000) (in Japanese).

Today and future trend for the utilization of recycled wood, agricultural wastes, and the zero-emission processes for the rubber/oil palm plantation plants were introduced.

Kawai, S.: **Activity of LCA section committee,** *Wood Preservation (Mokuzai Hozon),* **27**(3), 137–138 (2001) (in Japanese).

The research project on life cycle assessment (LCA) for wooden bridge in the LCA Section committee was introduced.

Kawai, S.: **Service life of wood and the restoration of wooden cultural properties,** *Kozai Bank Com.,* **36**, 1 (2001).

The service life and durability of wood, especially the aging of wood was discussed in connection to the restoration of wooden cultural properties.

Yano, H., K.Mori, P.J. Collins and Y. Yazaki: **Effects of element size and orientation in the production of high strength resin impregnated wood based materials,** *Holzforschung,* **54**, 443–447 (2000).

The effects of low molecular weight phenolic resin impregnation and high pressure hot pressing (150°C, 30–100 MPa) on the physical and mechanical properties of wood were first investigated by using sawn wood prepared from a block of Japanese birch *(Betula meximowicziana).* Subsequently, the effects of element size and orientation were examined by using sliced veneers, particles and powder prepared from the remaining portion of the block. Due to the combination of resin impregnation and hot pressing under high pressure, the specific bending strength at 20°C and 65% RH of sawn wood increased 50% accompanied by enormous decreases in moisture content, and bending strength reached around 400 MPa. The mechanical properties of veneer laminated product did not differ significantly from those of sawn wood product. Among isotropic products, the highest bending strength at 20°C and 65% RH of plywood, particleboard and powderboard was 242, 166 MPa and 175 MPa, respectively. The difference of bending strength between

plywood and other isotropic products could be explained by the difference in element orientation, cross lamination and random distribution. Furthermore, the results for the particleboard and powderboard showed that when the resin impregnated elements were hot pressed under high pressure, a decrease in element size did not result in a decrease in bending strength.

Yano, H., P.J. Collins and Y. Yazaki: **Plastic-like moulded products made from renewable forest resources,** *J. Mater. Sci.,* **36**(8), 1939–1942 (2001).

The bark of fast-growing wood species such as Pinus and Acacia species contains a high amount of tannin, a renewable forest resource. In this study, the possibility of utilizing radiata pine tannin as a substitute for synthetic thermosetting resins in the production of moulded products was investigated. When tannin powder and wood flour (tannin : wood flour = 1 : 1 w/w) were mixed and moulded at 190°C and 100 MPa for 10 minutes, plastic-like moulded products with a modulus of elasticity (MOE) of 9 to 10 GPa and a modulus of rupture (MOR) of 60 to 70 MPa were obtained without further additives. Furthermore, when tannin and wood flour (1 : 1 w/w) were mixed in water and freeze-dried, tannin was partially impregnated into the wood flour, and the MOR of the moulded product increased by more than 10% compared with that of products produced without the impregnation process. The moulded products described above showed good water resistance. Moreover, an increase in wood flour content was found to upgrade the mechanical properties effectively, with a MOR of 90 to 100 MPa being obtained at 75% wood content, despite a reduction in water resistance.

Yano, H.: **High strength wood based materials,** Proc. The 3rd International Wood Science Symposium, p. 160, 1–2 November, Kyoto (2000).

The effects of the removal of matrix substances in the production of high strength wood were studied. Removal of lignin and hemicellulose under mild condition was effective increasing the specific bending strength by up to 45%.

Yano, H.: **High strength wood based materials,** Proc. 5th Pacific Rim Bio-based Composites Symposium, p. 151–156, 10–13 Dec., Canberra, Australia (2000).

High strength wood based materials were obtained by a combination of three processes: a) selection of raw materials based on their sound velocity evaluated with an ultrasonic tester, b) removal of lignin and hemicellulose by a $NaClO_2$ treatment followed by a mild NaOH treatment, and c) a low molecular weight phenolic resin impregnation and compression. Due to the low molecular weight phenolic resin impregnation and compression, the specific bending strength of wood increased by 50%. Removal of lignin and hemicellulose under mild condition was also effective increasing the specific bending strength by up to 45%. Eventually, when a German spruce specimen selected based on its ultrasonic speed was subjected to the resin impregnation and compression after removing by 35% in weight of matrix substances, Young's modulus and bending strength reached 62 GPa and 670 MPa, respectively at a density of 1.4.

Yano, H: **Trees feelings,** Annual report of the forum for wood relating to culture and environment, vo l.3, p. 20–23 (2000) (in Japanese).

The fundamental ideas in the production of advanced wood based materials were described and two new type wood based materials, high strength wood and wood flour moulding, were introduced.

Yano, H.: **The world strongest and weakest wood,** Wood as a material in 21th century, p. 47–48 (2000) (in Japanese).

Two new type wood based materials, high strength resin-impregnated compressed wood based materials and plastic-like wood flour moulding prepared without using any additives, were introduced as future wood based materials.

Yano, H.: **Wood for musical instruments,** Wood as a material in 21th century, p. 55–56 (2000) (in Japanese).

Acoustic properties of wood using for musical instruments and some chemical treatments to improve the acoustic properties were reviewed.

Novicio, L.P., Y. Kurimoto, M. Aoyama, K. Seki, S. Doi, T. Hata, S. Ishihara and Y. Imamura: **Adsorption of mercury by Sugi wood carbonized at 1,000°C,** *J. Wood Science* **47**(2), 159–162 (2001).

The ability of Sugi wood carbonized at 1,000°C to adsorb mercury was examined using aqueous solutions of mercuric chloride. Parameters studied include contact time, pH, adsorption temperature, and initial concentration of mercury in solution. Results showed that Sugi wood carbonized at 1,000°C could effectively remove mercury from aqueous solutions. The carbonized wood showed high adsorption ability for mercury at a wide pH range (pH 3–9), but its ability drastically decreased at pH 11. Adsorption decreased with increases in adsorption temperatures, indicating that the processes were exothermic in nature. Adsorption was found to follow the Freundlich isotherm model. The adsorption capacity of carbonized Sugi wood was comparable to that of commercial activated carbon.

Novicio, L.P., T. Hata, Y. Kurimoto, S. Doi, S. Ishihara and Y. Imamura: **Adsorption capacities and related characteristics of wood charcoals carbonized using one- step or two step process,** *J. Wood Science* **47**(1), 48–57 (2001).

Sugi *(Cryptomeria japonica)* wood powder was carbonized at varying temperatures by a one-step process up to 1,000°C and a two-step process using wood charcoal as the raw material up to 1,600°C. This study was conducted to evaluate the adsorptive properties of wood charcoal and discuss the mechanism of its adsorptive function in relation to the physical and anatomical characteristics of wood after carbonization. Anatomical characteristics of carbonized wood materials were directly observed under heating using an environmental scanning electron microscope (ESEM); the cell wall structures were analyzed by high-resolution transmission electron micro-scope (HRTEM). The

largest weight losses were observed at the highest temperatures, in both the one-step and two-step processes but leveled off above 800°C. Shrinkages in the tangential, radial, and longitudinal directions increased with carbonization temperature, peaking at 1,000°C. Direct observations by ESEM showed distinct shrinkage at around 400°C. The first trial observations by HRTEM on the changes in the ultrastructure of cell walls of wood charcoals were done, and it was assumed to affect the formation of micropores. Adsorption was found to follow the Langmuir isotherm model. With the one-step carbonization process, the iodine adsorption capacities of the carbonized wood powders increased with increasing carbonization temperature, peaking at 800°C, but decreased at higher temperatures. The wood powder carbonized at 1,000°C with the two-step process showed the highest capacity, but further heating up to 1,400°C drastically decreased the adsorption. The shrinkage of cells was related to the increases and decreases in its specific surface area. Specific surface area and total pore volume were evidently related to the adsorptive properties.

Hata, T., S. Sugi, N. Higuchi, Y. Imamura, S. Ishihara and H. Kajita: **Production of fire-retardant LVL by glue-additive treatment and evaluation of properties enhancement,** *Wood Preservation,* **26**, 183–189 (2000) (in Japanese).

Veneers with different thickness and moisture content were bonded with phenol formaldehyde resin mixed with ammonium borate octahydrate or bromo-phenol resin at chemical retention of 200 g/m^2. The cross section of the two layered LVL specimens were analyzed with X-ray photoelectron spectroscopy (XPS) in order to evaluate the distribution of the chemicals of fire retardants along the glue line. The brom was assumed to be moved from the glue lines while pressing and captured in wood cells, which was influenced by the initial moisture content of veneers. Wider distribution of the chemicals was detected in the specimens with higher moisture content than oven-dried ones by XPS analysis. The penetration of resin, which was affected by the initial moisture content and thickness of veneers, influenced the fire retardancy and thickness swelling properties.

Subyakuto, T. Hata, S. Kawai, Y. Imamura and I. Ide: **Anisotropic thermal properties of molded carbon phenolic spheres,** *J. Wood Science,* **46**, 16–21 (2000).

Anisotropic thermal properties of molded carbon phenolic spheres (CPS), a mixture of sugi wood charcoal powders and phenol formaldehyde resin molded with a hot press, were investigated. The effects of the carbonizing temperature, particle size of chars, and density of the CPS on thermal properties were discussed. The molded CPS specimens were measured for their thermal properties using the laser flash method in both horizontal and vertical directions. The configuration of the CPS was observed by scanning electron microscopy. Anisotropy of the thermal properties (thermal diffusivity and thermal conductivity) between horizontal and vertical directions of the molded CPS was much higher than that of the uncarbonized molded phenolic spheres. Therefore, converting wood into molded CPS is an effective way to enhance the thermal-anisotropy properties. More marked effects of the carbonizing temperature, particle size, and density were observed in the horizontal direction than in the vertical direction. Anisotropy in thermal properties of the molded CPS may be considered an advantage for developing a new fire-retardant material for wood composites.

Hata, T., Y. Imamura and D. Meier: **Fast Pyrolysis for potential recycling technology of waste chromium-copper-arsenate (CCA)-treated,** Wood (Ed. Y. Imamura: *High-Performance Utilization of Wood for Outdoor Uses*), Press-Net, p. 189–200 (2001).

Although the chromium-copper-arsenate (CCA) preservative has been replaced over by non-CCA type chemicals in Japan, CCA is representative of water-borne wood preservatives, and has been widely used in the world. The amount of CCA-treated wood discharged as waste from demolished houses is increasing because of the rebuilding accompanying the housing construction boom in Japan. Recycling or reuse of waste wood is an important issue in terms of the effective utilization of natural resources. In reality, most waste wood is incinerated due to the lack of a labor force and systematic approach for demolishing residential houses. Environmentally benign disposal technologies have to be developed. Fast pyrolysis is a promising technology for recycling waste CCA wood. Pre-experimental analysis on the release of volatile compounds during pyrolysis of wood was performed in order to investigate the effect of temperature on the release of arsenic from samples. The yield of oil increased while that of charcoal decreased with the rise of pyrolysis temperature. There was not much difference in the arsenic quantity at the target temperature of between 400°C and 500°C. It was found that arsenic could be accumulated in low-yield charcoal by careful selection of pyrolysis conditions.

Hata, T.: **Wood material science of thermal conversion,** *Wood Research* **36**, 51–59 (2000) (in Japanese).

The background and situation in the field of wood material science of thermal conversion is plainly explained.

Hata, T., K. Nishimiya, E. Kobayashi, H. Kikuchi and Y. Imamura: **Ultra-structureal investigation for new application of bio carbon,** *Proceedings of 2000 Powder Metallurgy World Congress* (PM2000, Kyoto), 1477–1479 (2000).

Wood of Japanese Cedar *(Cryptomeria japonica)* was carbonized at 700°C, then the carbonized wood powder with and without aluminum triisopropoxide was graphitized using direct pulse sintering method in order to develop bio carbon ceramics composite products with new functions. The bio carbon and the graphitization were observed by Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM). Different sizes of onion-like graphitic particles were observed in wood charcoal (bio carbon), carbonized at 700°C for 30 min. Electric pulse was directly applied to the powder of wood charcoal and the graphitization of bio carbon was confirmed by transmission electron microscopy. The well-known structure of graphite fibrils was preferentially

observed at the higher heat treatment temperature. Aluminum containing samples already showed graphitization at low temperature, which was shown by X-ray diffraction analysis. The thermal and electrical conductivity of alumina bio carbon composites improved compared to that of sintered charcoal. The higher concentration aluminum lead to higher thermal conductivity and electrical resistivity of the bio carbon ceramics composites. It can be said that aluminum is a sintering additive that drives the graphitization of the bio carbon by a catalytic action.

Hata, T., K. Nihimiya, P. Bronsveld, J.th.M. De Hosson, E. Kobayashi, H. Kikuchi and Y. Imamura: **Microstructural investigation of bio carbon composites by electron microscopy,** *12th European Congress on Electron Microscopy* (EUREM2000) Vol. IV, S57–S58 (2000).

The Microstructure of bio carbon and of bio carbon based ceramic composites from wood is studied. Japanese cedar *(Cryptomeria japonica)* was carbonized at 700°C, using a laboratory-scale electric furnace. Wood charcoal powder with and without aluminum triisopropoxide was graphitized using a direct pulse sintering technique. The results were analyzed by scanning and transmission electron microscopy and by energy dispersive spectroscopy. The well-known structure of merging and interlinking of graphite fibrils was observed preferentially at the higher heat treatment temperatures. In the samples containing aluminum spherical graphitic layers are formed around crystalline cores already at lower temperatures.

Subuyakuto, T. Hata, I. Ide and S. Kawai: **Thermal properties of carbon or graphite phenolic spheres and its application—Sustainable utilization of forest products: Socio-economical and ecological management of tropical forests—,** *Proceedings of the 3rd International Wood Science Symposium,* (Kyoto) p. 127–132 (2000).

Thermal properties of molded carbon phenolic spheres (CPS) were measured using laser flash method in horizontal and vertical directions. Effects of carbonizing temperature, density, and particle size on thermal properties of CPS were discussed. Anisotropy of the thermal properties between horizontal and vertical directions of the molded CPS was higher than that of the uncarbonized molded phenolic spheres. Anisotropy in thermal properties of the molded CPS may be considered an advantage for developing a new fire retardant material for wood composites. Application of graphite phenolic spheres (GPS) to improve fire performance of laminated veneer lumber joint (LVL) was carried out. The GPS sheets were overlaid on the metal plate of LVL joint in different sizes and locations. The LVL joint was exposed to fire from a burner with top flame temperature set at 800°C and loaded with a weight of 200 N as in creep test under fire. The results showed that the fire resistant performance of the joint was remarkably improved by GPS reinforcement. The size and location of GPS reinforcement have significant effect on the time to rupture of the joint.

Hata, T., K. Ishimaru, P. Bronsveld, J.th.M. De Hosson, E. Kobayashi, H. Kikuchi and Y. Imamura: **Electron microscopic investigation of biomass carbon during carbonization,** *Proceedings of the 27th Annual Meeting of Carbon Materials* (Ogura city), Dec., p. 72–73 (2000).

The Microstructure of bio carbon and of bio carbon based ceramic composites from wood was studied. The results were analyzed by scanning and transmission electron microscopy ad by energy dispersive spectroscopy. The well-known structure of merging and interlinking of graphite fibrils was observed preferentially at the higher heat treatment temperatures. In the samples containing aluminum spherical graphitic layers were formed around crystalline cores already at lower temperatures.

Nakayama, T., T. Hata, H. Yano and Y. Imamura: **Application of wood charcoal to control of humidity condition,** *Proceedings of The 12th MRS-J Annual Meeting Session A "New Plant Materials"* (Kawasaki city), Dec., p. 85–88 (2000) (in Japanese with English summary).

Moisture adsorption or desorption is one of the important characteristics of wood charcoals, and recently these properties have been practically applied for humidity control in wooden-houses. Control of the humidity conditions under the floor is considered to be the effective means to upgrade the long-performance of housing by suppressing the attacks by fungi and insects.

Wood powder with the size of 60-16 mesh from Japanese cedar *(Cryptomeria japonica)* was carbonized with an electric furnace in an N2 or Ar gas atmosphere. In the furnace, the heating rate was kept at 4°C/min until the target degree of carbonization, between 300 and 1,200°C, and carbonization temperature was sustained for lh. The wood charcoals were subjected to moisture adsorption and desorption tests using a humidity-controlled chamber.

The amount of moisture adsorbed by the wood charcoal increased as the carbonization temperatures were raised, and the samples carbonized at 1,000°C showed the maximum amount of adsorbed moisture. However, the amount of moisture adsorbed decreased again in wood charcoal carbonized above 1,000°C.

Imamura, Y.: **Durability of wooden house,** *Forestry Science (Shinrin Kagaku),* No. 29, 31–37 (2000) (in Japanese).

Progress and causes of deterioration of wooden houses were overviewed and improvement of their durability were discussed, considering humidity and water control, properties enhancement of wooden-materials and maintenance system of housing for extention of service-life.

Imamura, Y., Y. Yanase and Y. Fujii: **Non-destructive detection of wood degradation by monitoring of acoustic emission,** *Proceedings of the Korean Society of Wood Science and Technology Annual Meeting,* Seoul, April 20–21, 153–157 (2001).

A new method for the non-destructive evaluation of termite attack in wood and wooden constructions using acoustic emission (AE) monitoring is proposed. In AE monitoring, the slight elastic wave in the ultrasonic frequency range generated by the feeding of worker termites is detected by a sensitive piezoelectric sensor. The performance of portable equipment for both methods

in the laboratory and field tests is discussed.

Tsunoda, K., H. Watanabe, K. Fukuda and K. Hagio: **Effects of zinc borate on the properties of medium-density fiberboard,** *Proceedings of the 5th Pacific Rim Bio-Based Composites Symposium,* Canberra, Australia, December 10–13, 335–338 (2000).

Medium-density fiberboards (3oo×300×2.7 mm) were made from radiata pine with target zinc borate contents of 0.25, 0.50, 1.00% and 1.50% BAE (Boric Acid Equivalent). Zinc borate was incorporated into the fiberboards by introducing the chemical into the blender. Standard laboratory tests (JIS A 5905) demonstrated that any significant loss in mechanical and physical properties [modulus of rupture (MOR), modulus of elasticity (MOE), internal bond (IB), water absorption (WA) and thickness swelling (TS)] of the boards was not noticed within the range of chemical contents in the current investigation. Laboratory decay test using a monoculture of *Trametes versicolor* and *Fomitopsis palustris* showed that treated boards were well protected from both fungi at 1.00% BAE with a mean mass loss of lower than 3%, whereas 4.7% and 28.0% mean mass losses were recorded respectively with *T. versicolor* and *F. palustris* after the same exposure period (8 weeks). Below 0.50% BAE the treated board specimens were attacked by subterranean termite, *Coptotermes formosanus* to some extent (40% of the untreated boards), and increased zinc borate contents (1.00 and 1.50% BAE) could produce a good protection from the termite in the laboratory. Field trials should be planned to determine the performance of zinc borate-treated medium-density fiberboards under conditions simulating practical applications.

Kumagai, H. and K. Tsunoda: **Effect of anti-sapstain chemicals on spore germination of a sapstaining fungus, *Graphium* sp.,** *Mat. u. Org.,* **33**(2), 143–154 (1999/2000).

The effect of 7 anti-sapstain chemicals and their mixtures incorporated into a medium on spore germination of *Graphium* sp. was microscopically examined. The chemicals were also tested for their SH-inhibitory effect using a glutathione-containing medium. Spore germination of *Graphium* sp. was completely prohibited by 5 chemicals: IPBC, DCOI, MBT, chlorothalonil and TMSP. Non-SH inhibitors, carbendazim and TCP allowed some spore germination, producing deformed fungal growth. The latter two chemicals, therefore, seemed different in effect on spore germination from others. Chemical mixtures containing IPBC and/or carbendazim produced a good inhibitory effect on spore germination.

Tsunoda, K., Y. Hikawa and T. Yoshimura: **Efficacy of hexaflumuron as a bait-toxicant in the field using a transferred nest of *Coptotermes formosanus* (Isoptera: Rhinotermitidae),** *Sociobiology,* **37**(2), 261–263 (2001).

Performance of bait applications on the control of subterranean termites has been based on the survey of monitoring stations in most cases (Su 1994, Su and Scheffrahn 1996, Su *et al.* 1998, Grace *et al.* 1996, Forschler and Ryder 1996, Tsunoda *et al.* 1998), although it seems uncertain to conclude colony elimination until absence of live termites in the nest is confirmed. A direct examination of the termite nest is more reliable to confirm the elimination of termite colonies when this method is applicable (Lenz *et al.* 1996, Nakayama *et al.* 1998, Tsunoda *et al.* 1999).

A nest of *Coptotermes formosanus* Shiraki was excavated from their natural habitat and buried back into the ground in the field test site in Kagoshima Pref., Japan, and monitoring stations were installed concentrically around the nest in January 1995. The nest was left intact until recovery of termite activity was noticed in the early summer in 1996. The first triple-mark-recapture program was conducted using Nile Blue A as a dye marker during July-October 1996 and foraging population was estimated at 271,200±49,600. Bait application was then carried out from November 1996 to December 1997. Termites were not present at any monitoring station at the end of the bait application. However, it was not concluded that the elimination of the test colony because no unsound termites with milky-white body color were trapped at the monitoring stations before their disappearance and the amount of hexaflumuron consumed by termites (23 mg) was not considered enough to kill all colony members. Termites actually came back to the stations and those belonged to the test colony. This was confirmed by the method using a colony identification box, which was connected to the test nest with a PVC pipe on 4 March 1998, since some of the termites which were collected from the monitoring stations, marked and released back to the stations were present in the box in May 1998.

Second estimation of foraging population from April to July 1998 indicated the decrease in foraging population down to 142,600±19,600 possibly due to the effect of the first bait application. Second bait application started in October 1998 and no termites were found at any monitoring station in July 1999. Careful examination of the recovered test nest clearly demonstrated that the colony was completely eradicated after the total consumption of hexaflumuron amounted to 419 mg. This was equivalent to a consumption rate of 1.55 μg/termite individual, and the rate was much higher than those recorded with the same species in Florida (Su, 1994). Intermittent bait applications in the current investigation and the seasonality in termite activity at the test site might account for such difference in hexaflumuron consumption rates.

The present results strongly supported that the survey of monitoring stations method was reliable in determining elimination of colonies of *C. formosanus* as the method well reflected termite activity while bait applications.

Tsunoda, K.: **Method for evaluating the efficacy of preservatives under protected above-ground conditions in the field,** [In] High Perfromance Utilization of Wood for Outdoor Uses (ed. Y. Imamura), Report on Research Project, Grant-in-Aid for Scientific Research, 113–129 (2001).

In the course of our investigations to determine the efficacy of unfixed borates such as disodium octaborate tetrahydrate (DOT) under covered above-ground conditions in the field where two major Japanese

subterranean termite species [*Coptotermes formosanus* Shiraki and *Reticulitermes speratus* (Kolbe)] are found, an experiment was designed in cooperation with Forintek Canada Corp. and the University of Hawaii.

The test method proposed here is simple and easy to set up and inspect, using concrete blocks and feeder stakes. A wood sample of 10.5×10.5×40 cm is placed on hollow concrete blocks. Feeder stakes are driven into the soil through the hollows to attract termites so that a ca 0.5-cm gap is present between a stake and the wood sample to avoid direct transport of moisture into the wood sample through the stake. An assembled unit is covered with a PVC box to protect the unit from weather. DOT-treatment was shown to be effective at protecting lumber from termite attack for at least 4 years when treated at 2–3% BAE (w/w) in Kagoshima, Japan based on this method. The present results strongly suggest that borates may be useful for the preservation of wood components in the crawlspace of Japanese houses, and data on the loss of borates from treated wood may also support this idea. However, a further assessment is needed to draw conclusions regarding the long-term performance of DOT-treatment because borates become toxic to termites when they are ingested and termites might come back to the treated wood repeatedly.

Nobashi, K., Y. Nomura and K. Tsunoda: **Development process of a new anti-sapstain formulation and its present status with the relevant problems,** *The Int. Res. Group on Wood Preserv. Document,* No. IRG/WP 01-30257 (2001).

An anti-sapstain formulation, which contains 2-(thiocyanomethylthio)benzothiazol (TCMTB) and methylene-bisthiocyanate (MBT) as active ingredients, was developed by a technical agreement with Buckman Laboratories (Memphis, TN, USA) as an alternative to chlorinated phenols for the Japanese market. The formulation was commercialized as BAM 12 years ago. As anti-sapstain treatment is commonly conducted by momentary dipping at the Japanese sawmills and the treatment solution is repeatedly used, a high stability of the solution is required. Thus, a series of surfactants was screened to select the most suitable surfactant to meet the requirement. Laboratory evaluations showed that the newly developed product was effective against molds (*Aspergillus, Penicillium* and *Rhizopus*) and a sap-staining fungus *Aureobasidium pullulans*. When it was occasionally found ineffective against *Gliocladium* at lower treatment concentrations, a chemical additive (IPBC or carbendazim) was proved helpful to fill up the deficiency of effectiveness. This was also demonstrated in the field trials. This report additionally refers to the problems that were experienced during and after commercialization of the anti-sapstain chemical formulation BAM.

Grace, J.K., R.J. Oshiro, T. Byrne, P.I. Morris and K. Tsunoda: **Performance of borate-treated lumber in a four-year, above-ground termite field test in Hawaii,** *The Int. Res. Group on Wood Preserv. Document,* No. IRG/WP 01-30267 (2001).

We report the fourth year of fiedld study results from a protected above-ground field test in Hawaii simulating the sill plate (dodai) used in conventional Japanese housing construction. Filed tests were established in both Hawaii and Japan to examine the efficacy of disodium octaborate tetrahydrate (DOT, 2% and 3% shell and through) wood treatments. In Hawaii, chromated copper arsenate (CCA, 4 kg/m^3) and ammoniacal copper zinc arsenate (ACZA, 4 kg/m^3) were included in the test, along with untreated western hemlock and Pacific silver fir controls. Both field sites support active Formosan subterranean termites, *Coptotermes formosanus* Shiraki, although termite pressure is greater in Hawaii due to the uniformly favorable environmental conditions. This report update the three-year results previously reported to IRG (Grace *et al.* 2000). After four years, minor damage (visual rating of 7, where 10=sound and 0=failure) has been noted to five individual treated dodai (out of a total of 10 boards from 7 treatments) as follows: 2% BAE shell treatment (2 boards), 2% BAE+DDAC through treatment (2 boards), and CCA treatment (1 board). Between the third and fourth years of the test, only four treated boards progressed to lower visual ratings: one 2% BAE shell treatment (from 10 to 7), one 3% BAE shell treatment (from 10 to 9), and two 3% BAE through treatments (from 10 to 9). In contrast, all untreated control boards were virtually destroyed during the past 11 months of exposure. Mean ratings for all wood treatments ranged from 9.2 to 10. These four-year results suggest that each of the DOT, CCA and ACZA treatments would provide long-term protection of dodai from termite attack.

Muin, M., K. Tsunoda and A. Adachi: **Supercritical fluid (SCF) application to the preservative treatment of wood composites: Treatability and effect of SCF treatment on the strength properties of wood composites,** *Proceedings of the 3rd International Wood Science Symposium,* Uji, November 1–2, 193–198 (2000).

Potential of the use of supercritical fluid (SCF) carbon dioxide (CO_2) for the preservative treatment of five different wood-based composites was investigated. Liquefied CO_2 was firstly brought into a mixing chamber where biocide(s) and CO_2 were mixed, and then the solution was introduced into a preheated vessel in which wood composite specimens were placed. Treatability of the composites with SCF-CO_2 was examined under three temperature levels (25, 35 and 45°C) and two pressure levels [7,845 kPa (80 kgf/cm^2) and 11,768 kPa (120 kgf/cm^2)]. All treated materials showed no physical defects after treatment, which suggested that SCF-CO_2 immediately penetrated into the wood composites without any critical pressure gradient between outer and inner zones. The effect of treatment on the strength properties varied with wood composite types and treatment conditions. The SCF treatment occasionally resulted in the slight improvement of strength property of the wood composites. Further studies are underway to determine the optimum treatment conditions when biocides are incorporated.

Muin, M., A. Adachi and K.Tsunoda: **Applicability of supercritical carbon dioxide to the preservative treatment of wood-based composites,** *The Int. Res. Group on Wood Preserv. Document,* No. IRG/WP 01-40199 (2001).

Treatability of five structural-use wood-based composites (medium density fiberboard, hardwood plywood, softwood plywood, particleboard and oriented strand board) was evaluated when supercritical (SC) carbon dioxide (CO_2) was used as a carrier solvent. Treatments were conducted at three temperature levels (25, 35 and 45°C) and two pressure levels [80 kgf/cm^2 (7,845 kPa) and 120 kgf/cm^2 (11,768 kPa)]. Although small changes in weight and thickness of the wood-based composites were caused by treatments with SC-CO_2, all treated materials did not sustain any physical damage. These results suggest that the treatment conditions provided the immediate penetration of SC-CO_2 into the wood-based composites without any critical pressure gradient between outer and inner zones. Strength properties of the treated wood-based composites significantly improved after treatments in most cases. In contrast, a remarkable drop in strength properties occurred in oriented strand board specimens. Further studies are underway to determine the optimum treatment conditions using biocides incorporated into the mixing or treating vessel.

Yoshimura, T.: **Termite attacks and Hanshin-Awaji earthquake, termite control strategies in the history, Termite and housing environment, Termite control in harmony with environment,** [In] Termite and House (eds. Y. Imamura, K. Tsunoda and T. Yoshimura), Kaiseisya, Ohtsu, 19–28, 137–145, 147–155, 157–170 (2000) (in Japanese).

Termite attacks found in the houses destroyed by Hanshin-Awaji earthquake were described. In addition, historical and novel termite controlling strategies in Japan were briefly reviewed in relation to the housing environment.

Yoshimura, T.: **The 50th annual meeting of the Japan wood research society (Wood 2000 Kyoto),** *Cellulose Commun.*, **7**(2), 79–81 (2000) (in Japanese).

The outline of the 50th Annual Meeting of the Japan Wood Research Society (Wood 2000 Kyoto) was described with some analyses of the trends in cellulose research.

Yoshimura, T.: **Termites in the other side of the earth,** *Shiroari (Termites),* No. 123, 15–19 (2001) (in Japanese).

Termite researches presented at the XXI International Congress of Entomology held in Iguassu, Brazil was briefly reviewed with the description on termites in Brazil. A plantation project in Amazon conducted by the Japanese company was also introduced.

Yoshimura, T.: **Present status and future trends of termite controlling strategies in Japan,** [In] High Performance Utilization of Wood for Outdoor Uses (ed. Y. Imamura), Report on Research Project, Grant-in-Aid for Scientific Research, 113–129 (2001).

Two subterranean termites, *Coptotermes formosanus* and *Reticulitermes speratus,* are major pests against not only wooden constructions, but also other exterior materials in Japan. Although they have been commonly controlled by the application of insecticidal chemicals so far, strategies with less- or non- use of chemicals are now being intensively investigated in many countries. "Baiting" methods are now becoming popular in Japan as well as in the U.S. Many research efforts on physical barriers such as stainless steel mesh and gravel barriers, and biological control of termites with entomophagous fungi are also being paid for preventing termite invasion through crawl space characteristically existed in Japanese houses and on-site treatment, respectively. The positive regulation of the crawl space environment such as humidity control might contribute to produce an unfavorable condition for termites.

Yoshimura, T. and J. Azuma.: **Termite and cellulase,** [In] Dictionary of Cellulose (eds. Cellulose Society), Asakura-shoten, 326–331 (2000) (in Japanese).

Cellulases isolated form termites were reviewed with some descriptions of ecological and physiological characteristics of termites.

Yoshimura, T. and M. Takahashi: **Biological resistance of Zn-Al metal coated wood,** *J. Wood Sci.*, **46**(4), 327–330 (2000).

Sapwood blocks of sugi (*Cryptomertia japonica* D. Don) were coated with Zn (45%)-Al (55%) at the thickness of 20–30, 90–100 μm and 180–200 μm, and were served for choice and no-choice tests with a brown rot fungus, *Fomitopsis palustris* (Berk. Et Curt.) Gilbn. & Ryv. FFPRI 0507, a white rot fungus, *Trametes versicolor* (L.: Fr.) Pilat FFPRI 1030, and a pest termite, *Coptotermes formosanus* Shiraki. 20–30 μm thickness was enough to prevent attacks by both test fungi, whereas 90–100 μm thickness was needed for the protection of termite attacks. Exfoliation of the coating layers were observed during the wet-dry process in the tests. The results suggested that Zn-Al coating treatment was applicable as an alternative method for the protection of timbers from biological deterioration when combined with the vapor-protecting additional treatment.

Takahashi, M. and T. Yoshimura: **Recent development in the control of Japanese subterranean termites,** *Proceedings of the XXI-International Congress of Entomology (Book II),* Iguassu, Brazil, August 20–26, 855 (2000).

Two species of subterranean termites, *Coptotermes formosanus* Shiraki and *Reticulitermes speratus* (Kolbe), have been causing the great economic losses against wooden constructions in Japan. Because most of Japanese houses have crawl space under the first floor, the control of subterranean termites has been commonly done by soil and floor woodwork treatments with termiticides. Termiticidal water emulsion is usually applied to soil poisoning in crawl space, but use of termiticidal granule is starting for reducing the atmospheric concentration of chemicals in operation. For this purpose, several improved methods have been devised by using micro-capsulated formulations, foaming formulations, termiticide-treated sheets, and easy-hardening pastes containing termiticides. Formulations for woodwork treatment should contain termiticide and fungicide, and they are applied to timbers by pressure and/or superficial treatments. To control the humidity condition in crawl

space, slab concrete on soil is becoming popular in Japan. Humidity-regulating materials are also used in crawl space to make unfavorable condition for termites and fungi. Increased public criticism to man-made chemical products is supporting the development of alternative termite control. Setting of physical barriers using stainless steel mesh is being introduced from Australia, and anti-termite cup for floor post has been devised and marketed. The idea of IPM (Integrated Pest Management) for termite control has been considered for long years in Japan, too. Bait-toxicant system using inhibitor of chitin synthesis was introduced few years ago from U.S., and biological control using entomogenous fungi will be promising in combination with baiting techniques.

Yusuf, S., Y. Yanase, Y. Sawada, Y. Fujii, T. Yoshimura and Y. Imamura: **Evaluation of termite feeding activities by acoustic emission (AE) under various relative humidity (RH) conditions,** *Proceedings of the 3rd International Wood Science Symposium,* Uji, November 1–2, 173–178 (2000).

To evaluate the effect of relative humidity (RH) on the feeding activity of termites, acoustic emission (AE) monitoring was applied. Workers of *Coptotermes formosanus* collected from laboratory and field colonies were kept under various RH conditions or stepwisely-changed RH gradient with wood blocks, and the AE events generated from the blocks were monitored. The highest feeding activities were observed at 75% RH in both tests regardless of colonies. The laboratory colony showed a more distinct response against RH changes in comparison with the field colony. The long-term cultivation of the laboratory colony under stable conditions might cause the sensitive response to RH changes.

Takematsu, Y., T. Yoshimura, M. Takahashi, S. Yusuf and P. Sukartana: **Present status of an important pest termite genus, Coptotermes, in Indonesia,** *Proceedings of the 3rd International Wood Science Symposium,* Uji, November 1–2, 161–166 (2000).

Coptotermes is one of the most economically important termite genera that attacks wood and wood-based materials in South East Asia as well as in Japan and China. To control the target *Coptotermers* species by environmentally-sound methods with less-use or non-use of chemicals, detailed information on its biology should be obtained. We have surveyed *Coptotermes* species in Indonesia, and this is a report for the present status of *Coptotermes* of urban area in Indonesia.

Yanase, Y., Y. Fujii, S. Okumura, T. Yoshimura and Y. Imamura: **Effect of temperature change on AE generated by termite activity,** *Proceedings of the 3rd International Wood Science Symposium,* Uji, November 1–2, 179 (2000).

Temperature changes in the trunk nest of *Coptotermes formosanus* Shiraki were monitored using thermocouples with the detection of AEs (acoustic emission) generated by termite feeding activity. The highest AEs were detected in summer when the temperatures in the nest were from 30–35°C. No significant AEs was observed in winter when the temperatures were under 10°C. These results indicated that the temperature-depending termite feeding activity can be detected by AE monitoring.

Yanase, Y., Y. Fujii, S. Okumura, T. Maekawa, K. Suzuki, T. Yoshimura and Y. Imamura: **Detection of metabolic gas from termites using ceramic gas sensors,** *The Int. Res. Group on Wood Preserv. Document,* No. IRG/WP 01-20222 (2001).

To evaluate termite attacks in wooden constructions by detecting the metabolic gas from termite colony, the basic performance of three types of ceramic gas sensors (odor-, methane and hydrogen-selective sensors) was investigated. Four termite groups of different combinations of workers (100 to 1,000) and soldiers (10 to 100) of *Coptotermes formosanus* and a small specimen of Japanese red pine and/or wet paper were placed in a container to which the gas sensors were attached. We found that the concentration of gas detected by the hydrogen-selective sensor increased with the number of termites in the container. The performance of this sensor was not influenced by the gases released from the wood specimen. Similar findings were also obtained for the odor-selective sensor, but it detected odor not only from termites, but also from the wood. No significant increase in the gas concentration was noted using the methane-selective sensor, which we speculated may be due to the influence of the humidity changes in the container on the performance of this sensor. The variations in gas concentration associated with the termite activity are also discussed.

Yusiasih, R., T. Yoshimura, T. Umezawa and Y. Imamura: **Biocidal screening method of wood extractives by a direct use of cellulose TLC plate,** *The Int. Res. Group on Wood Preserv. Document,* No. IRG/WP 01-20226 (2001).

The applicability of cellulose TLC Plate (Cell-TLC) for the biocidal screening of wood extractives was evaluated. Wood meal (<60 mesh) from Nangka (*Artocarpus heterophyllus*) heartwood was extracted using hot methanol, and the crude extract was separated using Cell-TLC (50×50 mm). Two broad bands with a Rf value of 0.46 and 0.96 were found, and the bands showed completely different effects against a decay fungus, *Fomitopsis palutris* and a pest termite, *Coptotermes formosanus.* The band with a R_f value of 0.46 was preferentially consumed by workers of *C. formusanus,* and did not show any growth inhibition against *F. palustris* when Cell-TLC was directly exposed to the organism. On the contrary, the band with a R_f value of 0.96 showed strong feeding repellency against *C. formusanus* and growth inhibition against *F. palustris.* These results suggested that the Cell-TLC was useful for the biocidal screening of wood extractives consisting of many compounds.

Inoue, T., O. Kitade, T. Yoshimura and I. Yamaoka: **Symbiotic association with protests,** [In] Termites: Evolution, Sciality, Symbiosis, Ecology (eds. T. Abe, D.E. Bignell and M. Higashi), Kluwer Academic Publishers, Dordrecht, 275–288 (2000).

Progress in understanding the symbiosis between protests and termites has not matched that between prokaryotes and termites. Methods are now available for

the isolation of pure culture of trichomonads and hypermastigids, although only a few have been cultivated. Sufficient molecular data are now available to construct tentative phylogenetic trees. Molecular data indicate that these organisms are amongst the most primitive eukaryotes lacking mitochondria; the trichomonads also use a prokaryote-like 70s ribosome. In metabolic terms, more is known about the cellulolytic protests but only in outline.

Ozaki, S.K., M.K. Yalinkilic, Y. Imamura and M.F. Souza: **Effect of boron compounds-furfuryl alcohol treatment of wood on dimensional stability, termite resistance and boron leachability,** *The Int. Res. Group on Wood Preserv. Document,* No. IRG/WP 01-40195 (2001).

Sapwood blocks of Japanese cedar *(Cryptomeria japonica)* and Caribbean pitch pine *(Pinus caribaea)* measuring 20 (tangential)×20 (radial)×10 (longitudinal) mm were impregnated with furfuryl alcohol (FFA) by a vacuum-diffusion process followed by curing under heating. Boron compounds (boric acid, ammonium borate and ammonium biborate) were mixed in the impregnation solution of FFA. Antiswelling efficiency, water holding capacity and moisture exclusion efficiency were measured. Boron leachability was determined by ion chromatography with ten leaching cycles according to JIS 9201 (1992). The specimens were exposed to termite attack testing, before and after the cyclic leaching process. The results indicated that FFA imparted to wood greater dimensional stability when mixed with boron compounds. Boron when mixed with FFA behaved differently to boron alone treatment, although it was still leachable. The wood specimens treated with FFA-boron compounds were quite resistant to termites even after severe leaching.

Kiguchi, M., Y. Kataoke, P.D. Evans, Y. Kadegaru and Y. Imamura: **Pretreatments of wood surfaces for improving weatherability of clear finishing,** *The Int. Res. Group on Wood Preserv. Document,* No. IRG/WP 01-40196 (2001).

The clear film durability of wood is generally very short because of photo degradation of wood surfaces caused by UV through to the film. Pre-treatment of wood surfaces for protecting against photodegradation is very important for clear finishing system. In this study, some pre-treatments, ie; polyethylene glycol (PEG) and UVA grafting (2-hydroxy-4(2, 3-epoxypropoxy) benzophenone (HEPBP)), were applied to wood surfaces and evaluated the clear finishing durability at outdoors. PEG treatment showed good clear film durability at mild climatic places, however, less durable results were observed at warm and high humid or heavy snow area in Japan. UVA grafting to wood surfaces greatly improved clear film durability as well as chromium trioxide treatment. Mixtures of UVA, HALS and anti mould chemicals system showed to prevent for growing mould on wood surfaces finished with clear or light color exterior stain system.

Kiguchi, M., Y. Kataoka, M. Mori, S. Doi, M. Hasegawa, S. Morita, Y. Kadegaru, P. Ahola, G. Hora, K. Jenang, P.D. Evans and Y. Imamura: **Progress towards the development of a weathering map of wood in Japan,** [In] High Performance Utilization of Wood for Outdoor Uses (ed. by Y. Imamura), Report on Research Project, Grant-in-Aid for Scientific Research, 1–13 (2001).

A weathering map of wood in Japan was developed using weight loss of thin wood veneers exposed outdoors at across Japan. A climate index (CI) for degradation of wood surfaces during weathering was calculated by multiple regression analysis of weight loss data. The most important climatic factor accounting for weight losses of veneers was monthly average maximum temperature which was responsible for about 50% of weight losses. The next most important factor was the number of rainy days in a month, followed by monthly precipitation, monthly sunshine hours, and average monthly solar radiation. A climate index for some cities in Japan was calculated using climatic data and a preliminary weathering map of wood in Japan was developed.

There was not a clear relationship between CI and deterioration of finished wood specimens during exterior exposure. Further research is needed to establish the relationship between weight losses of wood veneers exposed outdoors and the durability of finishes on wood.

Ohba, N., Y. Tsujimoto and Y. Imamura: **Development of accelerated outdoor-exposure test method of soiling and evaluation of algal growth on exterior materials,** [In] High Performance Utilization of Wood for Outdoor Uses (ed. by Y. Imamura), Report on Research Project, Grant-in-Aid for Scientific Research, 55–64 (2001).

We developed an accelerated outdoor-exposure test to establish a method for the assessment of algal growth on construction materials. In this test, water mist containing ammonium hydrogen phosphate as a nutrient was sprayed over the samples. The state of algal growth and the algae species observed were in close agreement with the results of field investigations of buildings and exterior materials. This method, which allowed evaluation of algae in samples in 3–5 months, was judged to be appropriate for reproducing algal growth in a short period. When algal growth on exterior materials was evaluated using this accelerated outdoor-exposure test, samples that absorbed water more readily tended to be more prone to algal growth regardless of the material.

Sudiyani, Y., J.Y. Ryu, N. Hattori and Y. Imamura: **Phenolic resin treatment of wood for improving weathering properties,** [In] High Performance Utilization of Wood for Outdoor Uses (ed. by Y. Imamura), Report on Research Project, Grant-in-Aid for Scientific Research, 85–96 (2001).

Phenol-formaldehyde (PF) resin treatment was applied to wood to improve weathering resistance against sunshine and rainfall for out-door use. The molecular weight of the resin was proven to affect the biological resistance as well as dimensional stabilization, and resin with a molecular weight below 500 was assumed to provide sufficient protection. PF-resin treatment improved the surface resistance of wood such as color stability, physical performance in cracking and hangnail test, and biological resistance after weathering. The surface portions of wood blocks were selectively and thoroughly incised by CO_2 laser, and then the resin was impregnated and compressed

while heat-curing to suppress the degradation of the wood surfaces by weathering.

Ozaki, S.K., M.K. Yalinkilic, Y. Imamura and M.F. Souza: **Effect of combined boron compounds and furfuryl alcohol treatment on termite and decay resistance in wood,** [In] High Performance Utilization of Wood for Outdoor Uses (ed. by Y. Imamura), Report on Research Project, Grant-in-Aid for Scientific Research, 97–103 (2001).

Japanese ceder wood blocks were impregnated with furfuryl alcohol (FFA) mixed with boron compounds (boric acid, ammonium borate and ammonium biborate), followed by curing by heating. The specimens were exposed to termites and decay fungi, before and after the cyclic leaching process. When boron was mixed with FFA, it behaved differently to boron alone, although it was still leachable. When FFA was combined with boron compounds, the mobility of boron slowed-down in all cases compared to boric acid alone treatment, and even after leaching, boron remained.

Miyatake, A., Y. Imamura, Y. Iimura and K. Fujita: **A case study of inspection for deterioration of timber bridge,** [In] High Performance Utilization of Wood for Outdoor Uses (ed. by Y. Imamura), Report on Research Project, Grant-in-Aid for Scientific Research, 161–170 (2001).

The assessment of the extent of degradation is of particular importance for an existing timber bridge to maintain the durability and the structural safety. Inspections can be classified into dayly inspections, routine inspections and detailed inspections. More effective and less costly repair methods can be attained by combining visual inspection with a few inspection techniques using instruments.

Iida, I., U. Watanabe, H. Nishioka and Y. Imamura: **Improvement of liquid penetration of wood by precompression treatment,** [In] High Performance Utilization of Wood for Outdoor Uses (ed. by Y. Imamura), Report on Research Project, Grant-in-Aid for Scientific Research, 179–188 (2001).

A new system for enhancing the penetration of liquid into wood using a precompression treatment was designed, and the effects of compressive deformation and recovery on liquid uptake were evaluated. Precompression with large deformation under appropriate moisture and heat conditions, and with optimum press schedules effectively increased the penetration of liquid into refractory wood samples of practical sizes without producing any strength reductions. Fracture of pit membranes during compression with little damage to unpitted cell-walls was believed to improve liquid penetration with negligible compression defects. A cyclic roller-press machine was newly designed and manufactured to evaluate the effect of precompression treatment on practical preservative impregnation of the dimension lumbers.

Sudiyani, Y., S. Yusuf, H. Kajita, Y. Imamura, M. Takahashi and Sudijono: **Enhancement of weathering properties of particleboard by phenolic resin treatment,** *Proceedings of the 3rd International Wood Science Symposium,* Uji, November 1–2, 188–192 (2000).

This study evaluates the weathering properties of particleboards treated by addition of low-molecular weight PF-resin (330 Mn) to the glue adhesive (PF, 1,010 Mn) after outdoor exposure in a tropical climate for more than 18 months. Phenol-resin-treated particleboards were made from the flake-type particles of the fast-growing trees, albizzia *(Paraserienthes falcate)* and rubber wood *(Hevea brasiliensis)*. The particles were treated with the low molecular weight PF resin and then sprayed with conventional adhesive-type resin. The target levels of resin loading were 5, 7.5% and 10% and the loading of adhesive phenol resin was fixed at 8%. The physical and mechanical properties of the specimens were determined before and after weathering. The biological resistance of these specimens before and after weathering was also evalrated by decay test using *Fomitopsis palustris* and *Trametes versicolor.* The results indicated that IB strength and MOR increased with resin loading and these properties were well maintained after 18 months exposure. Biological tests revealed that the low molecular weight resin worked well to enhance the decay resistance of particleboards in proportion to the resin loading.

Yusuf, S., I. Iida and Y. Imamura: **Improvement of liquid penetration into tropical hardwood by precompression treatment,** *Proceedings of the 5th Pacific Rim Bio-Based Composites Symposium,* Canberra, December 10–13, 718–726 (2000).

Impregnation of wood with liquid chemicals is a common technique for enhancing the properties such as dimensional stabilization, biological resistance and fire retardance. However, it is not always easy to impregnate refractory wood specimens with such liquids evenly and deeply. A new system for enhancing the penetration of liquid into wood by precompression treatment was applied to tropical hardwood, and the effects of compressive deformation on liquid uptake and mechanical properties were evaluated. Air-dried and water-saturated woods were compressed perpendicularly to the grain at room temperature up to a deformation ratio of 70%, and then loading was released immediately after compression. For water-saturated wood, pre-set fixed wood was also prepared that was dried under fixation by compressive loading. To assess liquid penetration into precompressed woods, immersion in aqueous dye was performed.

Precompression treatment increased the water uptake of tropical hardwoods in comparison with untreated controls, and the amount of liquid penetration increased with increases of in the deformation ratio. Among the four species examined, Kecapi was the most easily and evenly penetrated with liquid even without precompression treatment. Liquid penetration into the heartwood of Nangka and Sengon was markedly enhanced by precompression treatment, and wood of the latter species was more easily deformed due to its low density. For the refractory wood species Kiguru, deformation of more than 20% was hardly attained due to its high density. The maximum deformation ratio to improve the liquid uptake was assumed to be 30% for woods of densities of more than 0.6. No significant reduction of bending strength was

observed for treated woods.

Komatsu, K.: **Flexural behavior of glulam beam edge-jointed by lagscrews with steel splice plates,** *Proceedings of the World Conference on Timber Engineering* 2000, Whistler, Session 6.4, p. 6.4.3-1–p. 6.4.3-8 (2000).

Flexural behavior of glulam beams which are edge-jointed by lagscrews with steel splice plates was analyzed by considering the transmission of compression stresses through the end-grain surfaces of glulam beams as well as non-linear load-slip characteristics of lagscrews which are connecting steel splice plates and glulam beams. Full-scale destructive experiments, in which constant axial compression force was applied for simulating the combined stresses distribution, showed that the proposed theoretical analysis gave a reasonable prediction for the non-linear flexural behavior of jointed glulam beams.

Komatsu, K., K.-H. Hwang and K. Hosokawa: **Structural performance of glulam semi-rigid portal frames constructed by a hardwood wedge joint technique–Lateral shear performance of portal frames subjected to static cyclic loading (I)—,** *J of the Japan Wood Research Society,* **46**(6), 573–580 (2000).

Three types of glulam portal frames were developed which differed in their column-to-base joints (S-type, T-type and U-type) but had identical beam-to-column joints. They are intended to be used in wooden residential structures with small shear wall area in a narrow frontage due to doors or other openings. In the base joint of the S-type frame, two steel pipes were inserted into the column and connected with hardwood wedges. In the base joint of the T-type frame, U-shaped steel gusset plates were inserted into column and connected with hardwood wedges. The base joint of the U-type frame was basically the same as that of the T-type, but a few drift-pins and steel side plates were added for strengthening the joint. Beam-to-column joints of all frames were composed of U-shaped steel gusset plates and hardwood wedges. Static push-pull cyclic loading tests were conducted on the portal frame specimens testing 3 replications of each type. The following conclusions were obtained: 1) Among the three different base joints, the T-type frame seemed to be most appropriate judging from both in initial stiffness and elasto-plastic shear resistance performance. 2) Strengthening of the U-type was not effective. 3) The performance of the S-type was intermediate between the T-type and the U-type. 4) By using a T-type portal frame for the narrow frontage of a wooden residential structure, it is possible to include a door type opening 1.94 m wide and 2.73 m high and at the same time obtain a virtual shear wall which is slightly stronger than a single timber brace of 3.0×9.0 cm cross section.

Komatsu, K.: **Research and developments of moment-resisting joints for glulam frame structures,** *Proceedings of The 3rd International Wood Science Symposium,* Kyoto, 7–14 (2000).

Research and development of glulam moment-resisting joint for glulam frame structures was one of the most challenging subject for the author. In this keynote report, previous researches and developments on the glulam moment- resisting joints done mainly by the author were briefly reviewed from the first attempt to the latest ones.

Komatsu, K.: **How timber bridges should be developed,** *Woodworking Machinery,* No. 189, 2–5 (2000).

Recent state-of-the-art on modern timber bridges was introduced from a bit critical view point. In the report, covered timber bridges were strongly recomended to be constructed from now on in Japan.

Koizumi, A., T. Sasaki, J. Jensen, Y. Iijima and K. Komatsu: **Moment-resiting properties of post-to-sill joints connected with hardwood dowels,** *J of the Japan Wood Research Society,* **47**(1), 14–21 (2000).

Moment-resisting properties of post-to-sill joints made with glued-in hardwood dowels were studied. Dowels of 12 mm in diameter made of hard maple *(Acer saccharum)* are glued into post and sill members of sugi *(Cryptomeria japonica)* glulam with polyurethane adhesives to make joint specimens. Assuming that joints fail by withdrawal of dowels, moment-resisting strength and stiffness of joints were predicted by considering withdrawal force of dowels and compressive stress perpendicular to the grain in a sill members. Withdrawal strength and stiffness of single dowels were derived from previous reports. Tests of joint specimens showed the possibility of controlling moment-resisting strength and stiffness by choosing proper arrangements of dowels in the joint area. The greatest strength was obtained by arranging dowels in the outer section of the joint area. In this case, predictions of strength and stiffness agreed well with experimental results. For example, the joint of 105-mm squares with 6 dowels in the outer section showed a maximum momnent of 3.49 kNm at a rotation angle of 38.9×10^{-3} radian, compared to a calculated strength and stiffness of 3.69 kNm and 38.6×10^{-3} radian, respectively. However, strength and stiffness for joints with dowels in the inner section were overestimated by the calculations. The reason may be explained as follows: The compressive stress at the edge of the joint area exceeded the elastic limit and the neutral axis moved toward the tension side, which caused a larger pull-out force for the dowels than calculated assuming elastic behavior on the compression side. Furthermore, bending forces would act on dowels when a joint rotated significantly. Racking tests of dowel-connected frames were conducted to verify their performance as shear walls. The test results of frame specimens without braces showed good agreement between experimental strengths and calculated estimations based on moment distribution among joints assuming rigid-joint frames.

Test specimens with braces failed by buckling of the braces, which showed sufficient withdrawal strength of the dowels comparable to metal fastners for post-to-sill joints.

Komatsu, K.: **Structural performance of glulam semi-rigid portal frames constructed by a hardwood wedge joint technique—Theoretical analysis of the lateral shear deformation of the portal frame (II)—,** *J of the Japan Wood Research Society,* **47**(2), 103–110 (2001).

Following report-I of this research, the T-type portal frame, whose column-to-base and beam-to-column joints

were connected by hardwood wedges and 'U-shape' steel gusset plate, was subjected to a structural analysis. The frame's deformation and proportional limit load were derived as closed form equations by applying the minimum energy principle and the virtual work method. The rotational rigidity of the column-to-base and the beam-to-column joints plays the most dominant role in the calculation of deformation and proportional load. It was also derived in closed forms by taking both the embedment behavior of hardwood wedge and the longitudinal deformation of glulam end-grain surface at the steel reaction support into consideration. Agreement between observed data for the envelope curve of load-deformation angle of the T-type portal frame and those predicted by the theoretical equations was fair. From this it was concluded that the theoretical equations derived in this report are nearly appropriate.

Mori, T., H. Isoda and A. Sasagawa : **The proposal of the model for estimating the flexural strength of the glulam beam and verification by experimental results,** *J of Structural and Construction Engineering,* No. **541**, 51–57 (2001).

A model for estimating flexural strength was proposed in this paper. The model traces destructive mechanisms conscientiously. Therefore it can be applied for the several kinds of glulams that consist of some dimensions, stress conditions and woods. The model means that a lamina of glulam is divided into minute elements in the direction of length and minute elements that have each strength according to knots, finger-joint or clear wood. The element disappears when the element reaches its strength against the applied load. The concentration of stress and progress of cracks can be traced by removing minute elements in this model. The maximum flexural strength of a glulam beam is calculated as the minimum moment among the sums of moments that all elements resist on the same dimension.

For confirming agreement of this model, Monte Carlo simulations were carried out. The estimated values using this model agreed well with several experimental data.